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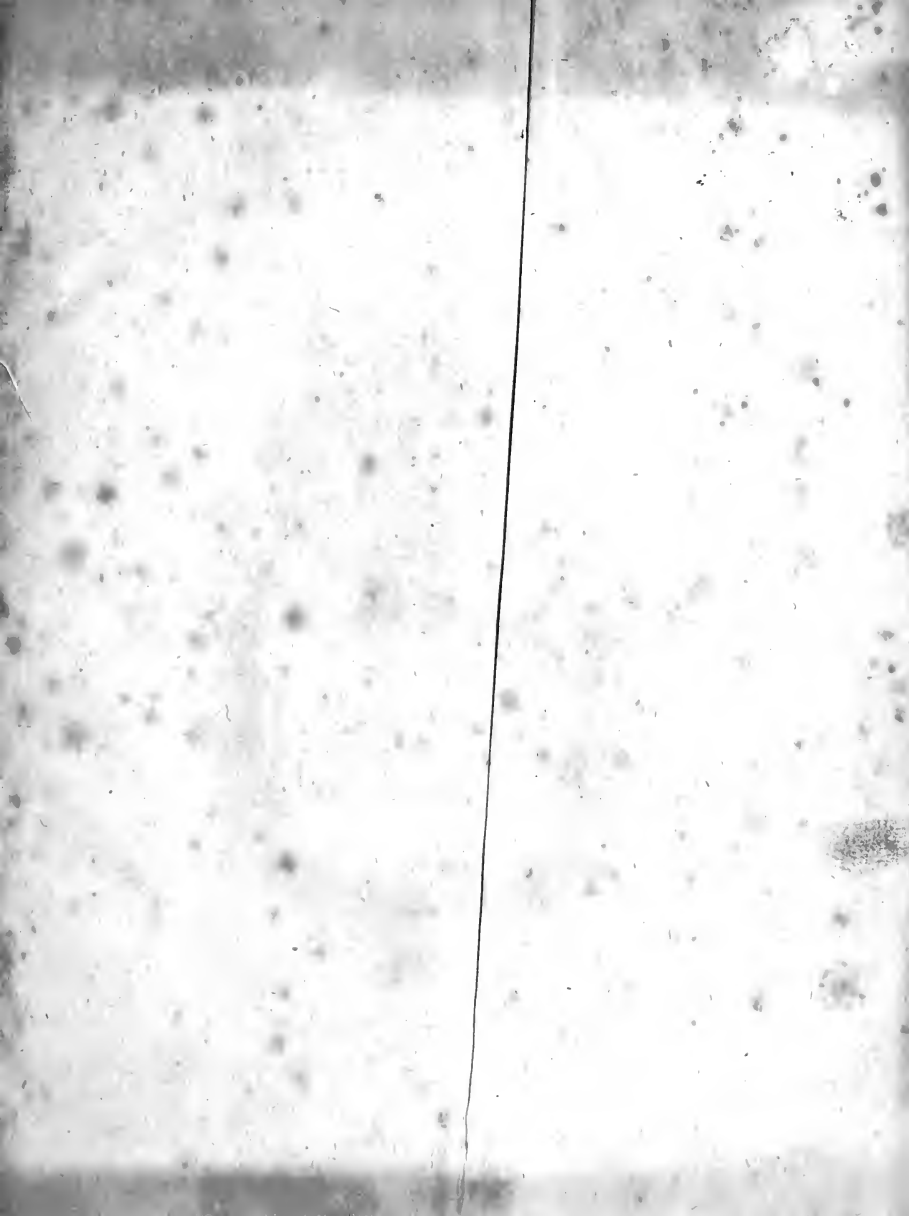


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T H E

V E G E T A B L E
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THE
VEGETABLE SYSTEM.

OR,
A SERIES OF
EXPERIMENTS, and OBSERVATIONS

TENDING TO EXPLAIN
The INTERNAL STRUCTURE, and the LIFE of PLANTS;
their GROWTH, and PROPAGATION;

The NUMBER, PROPORTION, and DISPOSITION of their CON-
STITUENT PARTS; with the true COURSE of their JUICES;

The FORMATION of the EMBRYO, the CONSTRUCTION of the SEED,
and the ENCREASE from that State to PERFECTION.

INCLUDING
A NEW ANATOMY OF PLANTS.

The WHOLE from NATURE only.

Lis.
By JOHN HILL, M. D. 1746-75.

L O N D O N:

Printed at the EXPENCE of the AUTHOR,

And Sold by R. BALDWIN, in Pater-Noster-Row.

MDCCCLIX.


Bot 357.59

HIS ROYAL HIGHNESS

PRINCE OF

TO
HIS ROYAL HIGHNESS
THE
PRINCE OF WALES.

MAY IT PLEASE YOUR ROYAL HIGHNESS,

ONSCIOUS of the Difficulty of this Subject, and of my unequal Talents, it is with great Diffidence I have presumed to lay before Your Royal Highness the following Researches: Yet, howsoever imperfect they may be found, I persuade myself they will not be denied the Honour of Your Sacred Patronage, since they tend to the Advancement of a Science which wants, and (if the humblest of its Votaries may be allowed to say it) deserves Protection :

Protection: which displays the GLORY OF GOD more than all others, because we understand it better; and demands an equal Preference in its Utility to Man; as it supplies the Means of Life, and Health; and furnishes many essential Articles, for the ARTS and COMMERCE.

THE certain Tendency of Botany to these great Ends, cannot fail to recommend it to the Favour of Your Royal Highness; since the World sees, with Joy and Pleasure, they are the Objects of Your highest Care. It is hence, we presage that they will continue to flourish among us; PIETY from Your own great Example; and COMMERCE under Your peculiar Protection. The Favour of Heaven thus obtained, we doubt not will give that Success to our Arms which shall command an honourable Peace, and its natural Attendant, lasting Prosperity.

MAY it please Your Royal Highness to pardon the Eye that looks thus far into Futurity; and sees, with Transport, the Fruit of your great Virtues; Virtues which would make common Men esteemed, but which must render a Prince adored: These promise, SIR, to make Your native Country not only the most powerful, but the most respected of the World; eminent

DEDICATION.

nent for Virtue, and for all Improvements : under their Influence, we doubt not we shall see Britain celebrated as the Land of Knowledge ; and the now famous Names of LEWIS and of COLBERT, eclipsed by greater of our own.

IT is with this View, we presume to hope, that the continued Patronage of SCIENCE, tho' the least, may yet be one of the many Glories attending Your great Name ; and that, when the Wreath of loftier Fame is filled, SHE may annex her Laurels ; which tho' light, are yet eternal.

I have the Honour to be, with the most perfect Duty,

may it please Your Royal Highness,

Your Royal Highness's

most humble

and devoted Servant,

LONDON,
May 4, 1759.

JOHN HILL.

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1911

THE
HISTORY
OF
BOTANY.



BOOK I.
INTRODUCTION.

Of the Origin of a Knowledge of Plants.

PLANTS must have been known, in some degree, at all times; for they could not escape man's observation. The Tree which gave him shade, the Fruits he eat, the grass that fed his cattle, could not be used un-named: nor is it possible he should neglect the fragrance of the Violet; or overlook the colours of the Rose and Poppy. The Poet could not paint the Spring without them; nor the first Shepherds tell their sons what Herbs their small flocks fed upon with health, or which infected them with sickness, till there were terms for their distinction.

THE origin of sciences lies hid behind that cloud which obscures all early History; but so much as here is said is plain from reason. We cannot doubt but before ORPHEUS or MUSÆUS, HESIOD or HOMER sung
VOL. I. B their

their qualities, the few Plants they have named were known among the peasants of their country; or that diseases had been cured by Herbs before the fabled CHIRON; or his days whom we see deified under the name of ÆSCULAPIUS: before the Hebrew SOLOMON, or SYRACH. What the CHALDEANS taught to docile ÆGYPT, they learned from some more early nation; and GREECE, which borrowed the Egyptian learning, owed the first rudiments of knowledge to that un-named people who were their teachers. The volumes of PYTHAGORAS on Plants were of avowed Egyptian origin; and those of that DEMOCRITUS they celebrate, were but other streams from the same source. In the mean time, while Learning laboured in the trodden path, the Savage taught himself: and GREECE and ROME, the seats of science and of power, found, like their younger sister BRITAIN, improvements even in their remotest conquests.

Thus, at all times, and every where, there must have been a knowledge of the Forms and Uses of some Plants: but this yet was not Botany. Greece gave the first outlines of a philosophic distinction; and that not in her earliest periods; for though HIPPOCRATES wrote usefully upon their Virtues, and the scarce known CRATÆVAS told their Forms, the Father of the science was THEOPHRASTUS. He the first of mankind, so far as history informs us, considered Vegetables in their Origin and Structure, their Principle of Life, and various Growth, and struck out from the chaos a Philosophy of Plants.

BOTANY had thus its first Establishment in ANCIENT GREECE, four hundred years before the Christian æra: and it was there considered as a science; a singular and very noble part of natural philosophy. Such it began, and such it ended, among that celebrated people. Instead of those advances and improvements which ought to have been expected under the ROMAN government, it drooped, and sunk into a trivial art; conversant in names alone, and the slight characters marked on exterior forms. The ARABIANS were the next who cultivated it; and they imperfectly: 'twas lost in the twelfth century, amongst the general WRECK OF LETTERS; and reviving toward the end of the fifteenth, with the RESTORATION OF LEARNING, grew again, in the SIXTEENTH, into a science, in the northern EUROPE.

WE are to trace its History thro' this extent of time; which its various conditions naturally divide into those six Periods.

PERIOD THE FIRST.

The Establishment of Science in ancient GREECE.

CHAP. I.

The BOTANY of THEOPHRASTUS.

THEOPHRASTUS, a great and a discerning writer, distinguished himself early among the GREEKS in Botany, and became the founder of the science. He studied Plants as a philosopher; those who wrote before him having considered little of them, except their medicinal virtues: He appears, therefore, in the honourable list of original Writers, and as the first of them on this subject. He studied Vegetables as Vegetables; searching, in their construction and appearances, their nature, origin, and cause of growth. On these enquiries he bestowed all that attention which distinguished him to the period of his very long life; and in declaring what he had thus learned concerning Plants, he disclosed all that eloquence for which his master, ARISTOTLE, named him the DIVINE SPEAKER. No EGYPT gave this parent of the science his first rudiments, nor did he adopt from any his design: his was a subject left untouched by his celebrated master in philosophy; and it was all his own: the book of nature lay before him, and in that only he appears to have read. From that alone he deduced those observations and definitions on which he established his system; and made Botany a science.

To view the exterior forms of Plants, to write an index of their names, or trace the nice distinctions of one species from another, in their minute organs, was no part of the undertaking: his was a greater subject; and to have known but one Plant, as he examined them, is greater than to have delivered the mechanic marks, or got by rote the more than the sesquipedalian names of our whole thirteen thousand. Those who object to this author's works, as imperfect, seem to mistake his purpose. To say he knew but a few Plants, is rash: for he has named those only which served his proper design. These are about five hundred; and it is more the modern indolence, than the obscurity of the subject, which prevents our

knowing what almost all of them were. That he says little of their virtues, can be no reproach; for he did not write on medicine. We own, and we lament, that his descriptions are often short; but neither was this any part of his design. He treated of the Laws of Vegetation in Plants commonly known; and he names them as such. We cannot foresee what may be the fate of letters: perhaps two thousand centuries hence, when after a vast space of renewed Barbarism, arts and power may have seated themselves in the remote AMERICA, some hasty writer may, in the same manner, arraign the British THEOPHRASTUS, HALES, for not giving the virtues of the SUN FLOWER; or describing more at large, the HOP-PLANT and the APPLE-TREE.

THERE remains yet one objection more to this great Founder of Botanic Knowledge; very general, but as unjust as these: it is the obscurity of his writings. We must not wonder this is often named; for it is a fashion to read Greek authors in the translations: and it has been the ill fate of this writer, to be most unhappily rendered into other languages. Even the elegant GAZA, tho' he has done justice often to the language of THEOPHRASTUS, has failed extremely in the articles of science: for only one who had studied the subject could, in this part, understand the author. Perhaps this difficulty might have been, in some degree, removed, if that BODÆUS, who happily, tho' tediously, illustrated some of the writings of this author, had not left the greatest work of all untouched. Those who will read THEOPHRASTUS in the original, will find these cavils vanish; and will in every part admire how vast a genius, and what observation he has disclosed; what attention to nature, and what discernment in her operations.

HE proposes his great undertaking as a philosophical, rather than an historical performance; and first treating Plants as Plants, not as of this or that peculiar kind, he seeks their nature and their laws only from themselves: deducing the new science from these four sources: 1. Their construction, and their natural and essential parts. 2. Their peculiarities. 3. Their origin and propagation. 4. Their life. This is indeed properly the whole subject: farther observations may shew more wonders in these several articles; and new discovered countries afford additional species, wherein to trace them; but the source and true foundation of the science lies in these four enquiries.

AFTER the common and received distinctions of the several natural parts of Plants, the ROOT, the STEM, the BRANCHES, and the like, he enters upon the construction of these, and their constituent matter. The essential

essential parts of Vegetables he accounts to be three; the BARK, the WOOD, and the PITH: a nicer distinction shews they are more numerous; for the Bark is double, and there is always a distinction of what he calls the Wood, into a HEART, and BLEA. This THEOPHRASTUS also knew: but a plain simplicity of thought, was his character in these researches. He treated the two barks as making but one substance, because the one is generated from the other; and it is the same in the Blea and Heart of Wood. This observation may be necessary, to prevent little cavils: but the philosophy is the same with or without the division. The enquiring spirit of this ancient sage did not stop here. As the Root, Stem, and the like, were natural to Plants, he found also certain constituent parts essential to each of these; and existent in them always. These he accounts to be four: 1. A fleshy substance. 2. and 3. Vessels of two kinds; which he calls Veins and Fibres; and 4. The fluid matter contained in them. We now know that there are also membranes; and that various juices fill the different vessels. All this he also knew certainly, for he could not discover so much as he has explained, without also finding this: but in the same strain of plain simplicity, he reduces these also to their principles.

THUS did THEOPHRASTUS, taught by just observation, construct the Vegetable body. These parts he determined to be essential to Plants, as Plants; and in this he adds, the universal Nature of Vegetables consists. A Plant being thus constructed, requires, says he, two principles of Growth: these are HEAT and MOISTURE. Consequently when these fail, the Plant decays and dies.

THIS is his general system. Not only the silence of history before the time of THEOPHRASTUS, gives us reason to conclude the philosophy was all his own; but his manner of expression also claims that honour. He is too modest to say of every article, this no one knew before; or this is my invention; but he complains, throughout the whole course of his enquiry, of the want of terms; of words and names for the objects which he saw, and for his own conceptions. If others had written of these things before, names would most probably have been established for them. He supplies the want of them usually by definitions; and borrows sometimes names for several objects from the known parts of animals; tho', as himself acknowledges, they are not altogether analogous.

A FIBRE, he defines to be a part of a Vegetable body, which is long, continuous, and fissile lengthwise; and which terminates without the production of a head, or any other natural part of the plant.

A VEIN,

A **VEIN**, he distinguishes as larger than a Fibre, long, hollow, and filled with a fluid; these also, he says, may be separated lengthways.

THE **FLESH**, he describes as spongy, shapeless, and equally capable of being divided in all directions.

A **BODY** composed of these parts, and capable of extension and growth, by these allotted means, Heat and Moisture, he defines to be a Vegetable. As very different Plants may be, and are constructed of these parts, and as the subject, when we proceed to the several species, becomes very copious, he adopts, for a familiar and plain general division, the received distinction into four kinds, according to the stature of the body, and firmness of its substance; **TREES**, **SHRUBS**, **UNDER-SHRUBS**, and **PLANTS**. Under the name Tree, he comprehends such Vegetables as are large, and rise with a single woody stem, as the oak: by Shrubs, he understands those which rise with many woody stems from the same root, as the Alder: by Under-Shrubs, small Vegetables with a single woody stem: and by Plants, such as have tender leafy stalks. The author expresses his sense of this distinction as vague and indeterminate, but, notwithstanding, useful: and so all authors since have judged of it. It is impossible to fix what are the distinctive characters between Tree, Shrub, and Plant; yet mankind have always conceived their absolute difference. The article of **SUFFRUTICES**, **UNDER-SHRUBS**, as we call them, has more perplexed those who adopted this division, than any other: but the character of these established by **THEOPHRASTUS**, which makes them Vegetables, more firm and durable than the herbaceous kinds, between the Trees and Shrubs in nature, but below both in stature, is, in some degree, correct. A **Suffrutex**, he says, rises with a single woody stem, but is low and little; and he gives Rue as an instance.

HAVING thus established a philosophy of Plants; and form'd, or adopted rather, a division of the species under a few natural classes, he proceeds to the second article of his original design, their **PARTICULARITIES**, their natural differences, and the effects of culture: and in all this he is clear, distinct, and full of knowledge. Among the Particularities or Affections of Plants, he considers largely the various places of their growth; Earth, Fresh Water, Sands, and Seas: and from this source he gives another natural and obvious distinction of them, analagous to that of animals; into Terrestrial, Aquatick, and Amphibious, naming many instances of each kind. To this article of the Particularities of Plants, he refers also the difference of their juices; their various tastes, and scents: searching these qualities in that original difference of their juice; and that difference itself

in the formation of the Plant. He has done this very happily : sparing of words, but full of sense and matter.

His commentators have indeed been, like modern Critics, rash and rude : they have depreciated their author, because they did not understand him : for there required to this a knowledge of the subject as well as of the language. Of this it will be just, at the close of the account, to give some instances. Having considered the Particularities and Affections of Vegetables in these and many other circumstances; deducing their qualities from their structure, according to his first philosophy, the author proceeds to their origin, generation, and production; in wild nature, or by the arts of CULTURE. In this article we must be astonished as we read, to find how much he knew : and we should blush at the small improvements of more than two thousand years.

THE propagation of Trees from Seed, from Suckers, and from Cuttings, even the most tender, was familiar to him : nay the very reveries of Ratiſbon Agricola, had their foundation here : for THEOPHRASTUS names the method of producing Trees from pieces cut from the roots, trunk, and branches. What appeared miraculous when the mad German proposed it to the world, might have been found earlier in this sober GREEK ; and Rome tried, and verified it in the Olive. So much we speak of the antique knowledge ; and so very little we examine what it was. Grafting and Inoculation, with all the lesser arts of Transplantation, and the mechanick processes of Culture, were known to THEOPHRASTUS. To take his sense entire, we must read his several works on the same subject together ; and we must read them in his own words, not in the strange translations, even of his best interpreters : thus we shall do him justice ; and we shall then learn, that the new things are old ; and learned labour is a thousand times employed, to revive a neglected practice, for once that it attempts to raise a new one.

FROM this general doctrine of Culture, THEOPHRASTUS descends to the particulars : he speaks with great and approved truth of Tillage and Manures ; and among his various instances of the effects of Culture, he gives that famous one, of making the Bitter Almond sweet. He treats largely of the Palm ; and we find he knew very well its different sex : and in the raising of the Fig, he explains, justly and truly, the strange practice of Caprifigation. He describes the Insects of the male Wild Fig, and tells us how they eat their way into the fruit of the other. The writers upon Plants of a late time, when they perceived the difference of sex in various Herbs of the same species, by a strange absurdity, gave the name
of

of *Male* to that which bore the Seeds: the *Cynocrambe* is an instance: but the Greek judged otherwise. He says, where the Plants are of two sexes, the *Male* is barren. There is also a peculiar thought upon this subject in his writings, worthy a nice regard, tho' propos'd with great modesty: it is, that Trees may be produced from their flowers, without the ripening of Fruit or Seeds. Let us be cautious how we reject this thought: It is strange, in the highest degree, but it is not absurd. 'Tis certain, that which grows into a new plant, is originally lodged in the *Farina* of the flower: and it is not impossible, in favouring climes, and in particular species, that THE FARINA MAY BE CAPABLE OF GROWTH. Perhaps, what we call Seeds in Fern, are globules of *Farina*; for we see no previous male flowers: most certainly the seeds, as they are called, of *Truffles* are of this nature: yet they grow. It is a doctrine to be propos'd with caution, but it is worth a tryal. He who gives the hint, has seldom been mistaken: and if there should be such a power in nature, we may propagate this way, perhaps, some of the best Trees in our Stoves, which flower with us, tho' they do not ripen seeds.

AFTER this doctrine concerning the Origin and Generation of Trees, in which, tho' faintly, and as it were, fearful of censure for the novelty of his opinions, he proposes many suggestions of the Original of Plants, conformable entirely to the philosophy which experiments are now about to establish, he comes to his fourth article, the Life of Vegetables.

THIS he conceives to exist in its first principles, in the Juices lodged within those vessels which he distinguishes by the name of Veins: and that as it is put in motion by the two principles, Heat and Moisture, the Plant enjoys a state of actual life; and grows. Having established the Life of Plants upon this principle, he proceeds to examine the different extent of it in various kinds, and the occasional decays which may effect it. This part of his works contains many and curious observations upon the Life, Health, and Distempers of Trees and Herbs. His observation that the Water Plants are shorter lived than those which grow on Land, is a general, tho' not an universal truth: nor is it less so, that wild Trees are longer lived than those of gardens. Abundant nourishment, in each case, gives a quick growth; but, like animal bodies over-fed, these are the more subject to disorders and decay. In deducing the causes of the distempers of Trees, he lays the foundation of most of them, upon an excess of nourishment; and attributes the immediate cause of several diseases, to sharp seasons after mild, in the time of their budding. What our late observations have done, numerous and particular as they have been, is prin-

principally the confirming the doctrines long ago advanced by this great man. He establishes Oil as the great Vegetable Poison; and gives this curious instance, that where Roots are cut, if they be rubbed with Oil, they shoot no Fibres.

THE Philosophy of Vegetable Bodies having been considered under these distinct articles, and the propositions relating to each, illustrated by plain, and often very singular facts, the author proceeds to treat of the more considerable and useful Plants distinctively: observing, that when the general laws of Vegetation are known, it will be easier to understand the effects which they produce in the particular subjects. Under these heads he has considered principally the objects of utility: he has treated largely and judiciously of the Esculent Herbs, particularly of the Corn and Pulse kinds; and the several methods of raising these, have led him to consider the Garden and Field Culture. We have accordingly in the succeeding chapters, the true Principles of Husbandry and Gardening. He lays down also the best Seasons for Felling Trees, and the Management of Timber; the Manner of preserving Gums, and other Medicinal Juices; and gives the original Way of Making Pitch and Resin: concluding his great work with a rational Account of Vegetable Medicines; and expressing a decent contempt for the fables and follies of an earlier time, relating to their growth, and to the manner of collecting them: every where conforming himself to nature.

THIS is a short view of what THEOPHRASTUS wrote concerning Plants. His work appears a vast and well considered undertaking; where the Philosophy of Vegetable Nature is made the basis of all succeeding knowledge; and is extended to whatever is useful in the parts of Plants, their Products, and their Culture. Upon the whole, we find that something was known concerning Plants before his time; but that knowledge was rude and indigested. Whatever former ages had discovered, we see collected and arranged in his several additional chapters, and carefully distinguished from his own. The first has its use: but the great value is in the latter. Others had seen things, he examined them; they had experienced, but he reasoned. We see him standing alone, in the vast space of Antiquity, with nothing before him, that deserves the name of scientific knowledge; and very slow advances after him. What he had done, discouraged for many ages, those who followed him; and while himself felt sensibly, and modestly acknowledged, that his advances were full of imperfection, referring the more accurate knowledge of things to succeeding times, and to repeated observations, his successors thought he had exhausted the whole subject:

ject. That there are some errors among this abundance of useful knowledge he has bequeathed the world, none can doubt: for what production that is human, is without them? but they are fewer than have been supposed: and it has been this author's ill fate, to be betrayed most of all by those who should have been his protectors; the great names *Gaza*, *Scaliger* and *Bodæus*, cannot disguise, nor should they hide this truth. A very little of the real excellencies of this Father of the Botanic Science, have been understood; and he has been censured for faults not his own. They have stumbled at the very threshold; and the worst accusations which have been urged against his knowledge, have arisen from their errors who rendered into other language his first chapter. One striking instance may stand in the place of many; and it will be justice to his memory to give one.

C H A P. II.

Of the GRECIAN BRYUM.

THEOPHRASTUS proposing to speak of the parts in Plants, distinguishes the permanent from those which are of short duration. Thus the root, the trunk, and branches of Trees, he observes, are permanent; but they have other parts which rise and fade within the year: such are the Flower, and those Films which cover and defend it in the Bud; the Fruit, and the like temporary products. The Buds of Trees, enclosing and defending the rudiments of their Blossoms, are composed of certain filmy substances, which fade as the Flower bursts forth; perish utterly when that tender part no longer wants them; and never are renewed. This cluster of filmy scales about the rudiments of a Flower, THEOPHRASTUS calls, in his own language, *Ἐγέρων*, a name which has been since rendered Latin, and applied to a peculiar Genus of the Mosses. *GAZA*, supposed an accurate translator, has rendered this word *Muscus*; and THEOPHRASTUS has been, in consequence, accused of thinking Moss a part and natural product of the Tree whereon it grows.

THE application of the word Bryum to that peculiar kind of Moss which is now called by it, is later by many ages than the time of this venerable author. The word was then the absolute name of a peculiar Plant, which THEOPHRASTUS himself mentions in its proper place; and it would have been impossible either that they should have thought the word meant Moss, or that THEOPHRASTUS thought the Plant it did mean, was a part
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of Trees, or ever grew upon them, if they would have taken him altogether; if they had read his fourth book before they had criticised his first.

THE Bryum of the ancient Greeks, was the Small Green Sea Weed, which the common Writers on Plants call *LACTURA MARINA*, and the vulgar, from the colour and place of growth, *OYSTER GREEN*. This Plant *THEOPHRASTUS* has not only named but described, in the seventh chapter of his fourth book, where he treats of the other Sea Plants. He refers it to the *ALGAS*, and says it is of a Grass-green colour, with a curled and spreading leaf, not unlike the curled Lettuce, but more waved and wrinkled: he adds, that it has no stalk, and that it grows under the seawater, but in shallow places, on stones and potsherds, which happen to be there. This then was plainly the Plant called absolutely Bryum by the Greeks; *ARISTOTLE* mentions it, and *THEOPHRASTUS* has described it: and it is impossible, that he who knew it a Sea Plant, should place it upon Trees at Land. The fact is this; the young leaves, or first shoots, of Oyster Green, being thin, filmy, and curled about, resemble not amiss those perishable films which make the substance of the buds in certain Trees: therefore the Greek calls that filmy matter in buds figuratively *Βρυον*, the Bryum of the Gems of Trees; and after him his countrymen applied it to the Hop, because that fruit is filmy; and to the Olive Bud; *Βρυον* was the term for the flowering of that Tree. *THEOPHRASTUS* laments frequently the want of proper terms and names for what he is to describe; and in the same manner as here from another Vegetable, he often forms them on the names of parts something like in the bodies of animals, acknowledging the imperfect and improper expression, but pleading the necessity. It is thus they are embarrassed who beat the untrodden paths of science; and it has happened often, that they are thus rewarded: but seldom by so respected names as those which join the censure upon *THEOPHRASTUS*.

THE word *Βρυον* was in after times used as the name of a TREE Moss, particularly of the long hairy kind. This is nothing to the subject when we are considering *THEOPHRASTUS*; tho', perhaps, 'twas this which led his Translators into the error. We find the meaning of the word absolute in his own writings: it was the name of that Sea Weed, and of nothing else, till himself used it figuratively for these films of buds. Indeed no term ever became more vague in its signification than this did afterwards. All Mosses, all Excrescences on Trees, and every thing of like kind, obtained the name of Bryum.

DIOSCORIDES, who wrote of Plants as Medicines, has limited the sense of Bryum to one of the Tree Mosses, us'd in some officinal compositions;

but the succeeding **PLINY** employs it in all its freedom. **THEOPHRASTUS** wrote when a little was known, and they who followed him for many ages, were very negligent on the subject: it is possible they may have founded gross errors on their slight notice of his distinctions; but justice to his memory requires of us to add, they did not find them in his writings.

PERIOD THE SECOND.

The State of the **SCIENCE** during the Government of the **ROMANS**.

CHAP. III.

The **BOTANY** of **DIOSCORIDES**.

HIPPOCRATES spoke of Plants as a Physician, and **THEOPHRASTUS** considered them as a Philosopher: **DIOSCORIDES** united the two subjects; and to serve farther the great purpose of utility, he added to what they had written, a great deal from his own experience: an author less original than either, but more generally useful; born, perhaps, with an inferior genius, but indefatigable and honest. To the five hundred Plants of **THEOPHRASTUS**, he added more than ninety: so that in his time the account stood at about six hundred.

ALL these were used in medicine, or in the œconomy of ordinary affairs: for the ancients of this period considered them only as worthy notice for that reason. The spirit of a philosophic enquiry into their nature, which seems to have been born with **THEOPHRASTUS**, died also with him. Assiduous observation formed the character of **DIOSCORIDES**; but this was more directed to the qualities and virtues of Plants, than to their outward parts, or their internal construction. For tho' he has endeavoured to describe most of those whose uses he relates, he has seldom done it perfectly. **GALEN** taught the world to look on **DIOSCORIDES** with reverence, when he claimed only respect; and tho' he deserves much praise, to give him more.

DIOSCORIDES lived long after **THEOPHRASTUS**; and there are some who place him later than **PLINY**; but this, tho' countenanced by many great names,

names, is plainly an error. **PLINY**, who was too much obliged to **DIOSCORIDES**, has no where named that author : for the ancients were less brutal than the moderns upon this occasion. Our authors when they plunder another, attempt also to destroy his character, that none may see their original : they only study'd to conceal the obligation : a practice printing has now made impossible. We owe **DIOSCORIDES** this justice : for tho' he was very far inferior to **THEOPHRASTUS**, he yet deserves a higher rank than **PLINY**. It may be proved that he was really the earlier ; tho' the same evidence will shew, that he preceded the other but a little in point of time. One instance may serve as a thousand. Where **PLINY** names the **HÆMATITE** and **SCHISTUS**, he translates the passage verbally, tho', perhaps, not happily, from the writings of **DIOSCORIDES** : he takes from this author exactly not only the description of those minerals, but their virtues ; and even the peculiar fluid wherein to mix them up for use : this is woman's milk. When **PLINY** has given this account, he adds these remarkable words : This is the opinion of those who have wrote latest on the subject. We see, by comparing the two authors, that it is distinctly and exactly the opinion of **DIOSCORIDES**, and plainly he was one of the late writers whom **PLINY** quotes, tho' he does not add his name. We know **PLINY** wrote under **VESPASIAN**, and this may fix the time of **DIOSCORIDES** : he, being a little earlier, must have written about three hundred and seventy years after **THEOPHRASTUS**.

TRACING the History of Botany, we thus find a period of near four hundred years in which no advance whatsoever had been made in the science : for **DIOSCORIDES** says nothing of the philosophy of Plants which was not known to **THEOPHRASTUS**. Every thing appears to have been darkness before that writer ; and all neglect and indolence during so many ages after him. The Science of Botany began with him, and in a manner ended where it began. The succeeding Greeks appear not to have regarded his discoveries, or even to have preserved with any accuracy, the very names by which he and their other predecessors called the several objects. In this long period between **THEOPHRASTUS** and **DIOSCORIDES**, only one hundred Plants were added to the stores of knowledge ; and these, as will appear by that last author, were but ill known, and carelessly distinguished.

DIOSCORIDES found Botany little regarded, the philosophic knowledge of earlier times neglected, and the uses of a few known Plants only studied. He conformed to the custom of an indolent age, whose attention he might, if he had pleased, have extended to this other path ; and what he

has

has written, is regardless of science, and established upon the sole basis of utility. Even his arrangement of the subjects, is made on this foundation. He considers Herbs as Medicines; no otherwise: and has mixed the accounts of various kinds together, as he found direction in their common virtues. Thus defective is *Dioscorides* as a Botanist; but as a Physician he is highly valuable.

He considers the use of Medicines as directed to two purposes; the preservation of health; and its recovery, when assaulted and impaired by diseases. He supposes aromatics to be the greatest preservatives, and first treats of them; arranging them all-together. This is his original purpose; but he has not neglected the consideration of their forms entirely. Usually Plants of the same natural class, have the same virtue: therefore they are in general united by a double band: but when two Plants are alike in qualities, and unlike in form, *Dioscorides*, giving the resemblance of virtue the first place, keeps them together. His writings, therefore, were more adapted to instruct the Physician than to form or to improve the Botanist: and such he intended them. This has its fair excuse, when we consider the nature and genius of his work: but there is one compliance with vulgar custom which he has made, and which is less pardonable. If the common phrase of the people called two distinct Plants, which had no resemblance, either in form or virtue, by the same name, he has also kept them together; forgetful that an author of his rank should have improved the public taste, and not have soothed it in these mischievous errors. He seems to have paid some regard to the established distinction of Vegetables into Trees, Shrubs, and Herbs; a natural, tho' incorrect, distinction, which obtained in and before the time of *Theophrastus*; but this, like all other distinctions of form, he has made subservient to the agreement of Plants in their qualities: neither has he concerned himself about any arrangement or distinction according to their parts or forms.

Dioscorides has had the fortune to be named among the Fathers of the Science of Botany; but it is certain he did absolutely nothing toward its advancement. The knowledge of Medicine in his time, owed to him great things; but the science of Botany not the least improvement. It appears to have had one, and but one, great parent, *Theophrastus*. The writings of that author were open to *Dioscorides*; but his plan did not require that he should use them: nor did his genius lead toward those researches, into which the other had opened a plain tho' utterly neglected path. As to the knowledge of particular Plants, it is thought the world owes much to *Dioscorides*, because he has given longer descriptions than the elder
Greck;

Greek; but more of this appears than is real: the descriptions of THEOPHRASTUS, tho' very short, are distinct, and expressive: those of DIOSCORIDES, tho' they consist of many words, and promise great distinction, yet are perplexed in the expression, and often confused with circumstances that cannot be reconciled to the rest of the account. It may be proper to produce one instance. In his history of the Plant *ζα*, he gives a description containing many articles, and which, tho' not altogether free from confusion, yet, in the capital points, agrees so perfectly with our GARDEN VALERIAN, that it appears evident this species was meant; till we come to the last sentence, in which he says, its Flower is like that of the NARCISSUS, but larger, and more delicate. What should we think of a Valerian with Flowers like Daffodills, but as a creature of the author's fancy? A monster not to be produced by nature! Yet it is certain, this celebrated Greek has raised an Herb, whose Root, and Stalk, and Leaves are true Valerian; and hung upon it these, as it would appear from the expression, Enormous and Preposterous Flowers. It is plain, that DIOSCORIDES knew the Daffodill, and knew it by the name *ναρκισσος*, Narcissus; for he has described it carefully, in the same work: distinguishing the two peculiar kinds, that with the yellow, and that with the red inner circle. But the difficulty may be explained. *ναρκισσος* was the name of Daffodill in DIOSCORIDES's time; but it had been early given to another, and that a very different Plant; one that has so much of Valerian in the Flower, that it is called to this time RED VALERIAN. The name *ναρκισσος* still continued to be used for that Plant, as well as for the Daffodill, when this author wrote; and it is not a rash thought, that this Plant, and not the Daffodill, is what he meant here; and was also the Narcissus of the Roman Poets.

VIRGIL may have meant this Red Valerian, in all the places where he has named Narcissus: and he certainly does in many of them. The Narcisso Floreat Alnus, in the Eighth Eclogue, may mean any Flower; for there is no character or descriptive mark annexed to the name there; and in the second, it is mentioned as indistinctly. But there are other passages where something more is said; and all agreeing not with the DAFFODILL, but RED VALERIAN. When in the fourth Georgick, he names the Tears of the NARCISSUS, and the tough and viscous juice of its rind;

NARCISSI LACRYMAM ET LENTUM DE CORTICE GLUTEN;

and employs the bees in gathering it for the foundation of their combs; it is probable, he means RED VALERIAN, of which bees are very fond, and

and in the rind of which, toward the bases of the Flowers, there is a very tough juice : for the Daffodill is not of the number of their favourite Herbs. The *Purpureus Narcissus* of the fifth Eclogue also, is more likely to mean the Flower of this Plant, which is entirely purple, than that of the Purple circled Daffodill, the principal part of which is white : and finally, when in the fourth Georgick he adds, the time of the *Narcissus* blowing, and a descriptive mark of its tufted Flowers,

SERA COMANTEM NARCISSUM,

it is not probable he meant the Daffodill ; because tho' there are late flowering species, the ancients celebrated only those of Spring : nor is it possible he should give the epithet *COMANTEM* to any *NARCISSUS*, except the Red Valerian. The Romans expressed by *COMA*, the Tufted Summit of a Plant, formed of numerous little Flowers, and resembling, in some degree, a head of hair : this agrees with the Red Valerian, but is wholly unapplicable to the Daffodill. Columella, in his book of Gardens, is yet more distinct, he calls the Flowers of the *Narcissus*,

NARCISSI COMAS.

Alluding plainly to their Slenderness, and Number on the Stalk, which even in the Many-flowered Daffodills is small, but in the Red Valerian very great. It has been proved abundantly, that what the Latins meant by *COMA*, speaking of Plants, was a complex Tuft, made of innumerable small Flowers. They called the Panicle or Tuft of the Reed first by this name ; and afterwards whatever was formed like it ; whence afterwards the Poets applied it figuratively to the innumerable Leaves which formed the bushy heads of Trees. The slenderness and length of the *RED VALERIAN* Flowers agree happily with the idea of hairs ; but there is nothing in the Daffodill that bears the least allusion to them.

UPON the whole, there is the greatest probability, that the ancients gave the name *Narcissus* both to the Daffodill and Red Valerian ; as we even yet give the same name, in many cases, to two Plants absolutely different. It is impossible *DIOSCORIDES* could compare the Flowers of Valerian to the first of these, the Daffodill : but none can wonder he should liken them to those of the latter ; which, tho' it was plainly known to the ancients, has no other name among them : late writers have made it a Valerian, from the resemblance of its Flowers to those of this very Plant.

THIS

THIS reconciles the difficulty; for the Flowers of Wild Valerian are not only like those of this Narcissus, but their difference is exactly what DIOSCORIDES expresses; they are larger at the opening, and their colour is not a bright red as in those; but a whitish Purple. If this be the case, and this the Plant to which the Valerian Flowers are compared by DIOSCORIDES, tho' the resemblance be sufficient to justify the comparison, the author is inexcusable in referring to an Herb under the name Narcissus, which himself has no where mentioned or described; when he had treated at large of another Plant, the DAFFODILL, which is not the thing here meant under the name Narcissus: it could be only thought that he referred to the Plant of which himself had treated by this name, when he used it in the present instance; but it appears too plainly, that it was to the Narcissus of other and earlier authors he resembled Valerian, and not to the Plant himself had described under that term. From this, and other circumstances too like this, it appears a doubt to me, whether DIOSCORIDES understood, or had ever studied Botany. The nature of his undertaking led him to speak of Plants; and he did well and wisely to annex descriptions; but to ascertain their virtues was his great aim: and it is not improbable he collected from others those accounts which he has given us of their forms, and colours. I would not depreciate a venerable name; nor has this observation, properly, any such tendency. DIOSCORIDES proposed himself to the world as a physician, and he appears to have been a very great one; but he plainly was no Botanist.

THEREFORE we still see the long period of the neglect of Botany continued. Four centuries had passed from THEOPHRASTUS to the time of DIOSCORIDES, and no advance had been made: even this great man, whose extensive undertaking led him to treat of Plants, yet considering them only as medicines, added but a few to the Objects of the Science; and nothing to its progress in Philosophy.

CHAPTER IV.

The BOTANY of PLINY.

AS we know nothing of Botany as a Science before THEOPHRASTUS, the Grecian empire gave the world no author after him: the subject seems to have slept among the polished world from that time to the period of the Roman Pompey. His victory over Mithridates, gave it a

new birth among the world of letters. What that celebrated prince knew of Plants, and of their virtues, appear'd of so much importance to the wise Romans, that the Conqueror ordered the writings of Mithridates to be translated by Lenæus; and men applied, in some degree, to the study: yet they made small advances. CATO, and VALGIUS, and VARRO, are the principal names celebrated on this account: but a few observations on the virtues and æconomical uses of a very small number of Herbs, was all the world obtained from their researches. ANTONIUS MUSA and EUPHORBUS, born, as it should seem, to bring the Grecian medic arts to Rome, grew famous about the same time. The former of these is celebrated for a treatise on the Plant Vetonica, the first of the Botanical Monographi. We have the name also of an ÆMILIUS MACER, of whom we read in Ovid, and who wrote in verse of Plants; but by all we know, this also was limited to their virtues; a poem not botanic but medicinal. BASSUS and NIGER wrote in Greek of Plants, some small time before DIOSCORIDES, but if that author's account of them be true, if the one was prolix and idle in his manner, an ignorant and injudicious compiler; and the other took Aloe to be a mineral; we need not much lament the loss of what they wrote. These COLUMELLA followed, eminent for his account of the ancient Husbandry; but what he has written of the Field Plants, or Garden Flowers, adds nothing to the Botanic Science. Of DIOSCORIDES we have spoken; and a small period after him came PLINY.

THIS name, treated too often with an implicit reverence, Truth, and a strict enquiry into the History of Botany, would oblige Candour itself a little to prophane. PLINY must not be ranked among the original writers; nor can it be said this science owed to him any new light, or the least advance toward improvement. His merit is that of a Collector only; but as he gathered from the writings of authors now lost, his work is highly valuable. Perhaps the botanical part has less worth than most of the others; but this, if used with caution, is not without its merit. As he collected generally, all that he has put down is not of equal authenticity. The works of THEOPHRASTUS and of DIOSCORIDES plainly were before him; and he has taken from them largely: other strange matter has its place among what he has thus collected; and probably we owe it to the Bassus and the Niger named before, or to one or other of those authors, whom, tho' not much to their honour, DIOSCORIDES quotes as having written a little before him, JOLAS, and TARENTINUS NICERATUS, another NIGER, and a DIODOTUS condemned to eternal memory, by their imperfections. All these were before PLINY; therefore he might use their writings, and by a great deal

deal of his matter, and their characters, it is probable he did; therefore tho' his great work is an epitome, as it were, of the Grecian and early Roman knowledge, it must be used with extreme caution, or it will lead the reader into strange errors. It is evident, he understood no Botany; nor had any knowledge of the Plants concerning which we find so many chapters in his work; he owed principally to the Greek writers what he has said of them, and unhappily he was but a very indifferent master of their language. This appears plainly, because we have the originals in many instances, and can judge of his translations. These are the imperfections of PLINY; but guarding against the errors to which these might seem to lead, we find a great deal of knowledge in his work, not to be met with in the others.

FROM THEOPHRASTUS to DIOSCORIDES, tho' a period of between three and four centuries, BOTANY had been so little regarded, that not altogether a hundred Plants were added to the original Catalogue: but the account wears a new face, from DIOSCORIDES to the time of PLINY; and it is to that laborious Greek we probably are to attribute the advantage. His writings seem to have raised a spirit of enquiry in the curious world, upon a subject which had slept so long: And the period between him and PLINY, which cannot reasonably be accounted more than thirty years, added at least four hundred Plants. PLINY names, and in some degree describes, more than a thousand species. The subject is started in his twelfth book, and is continued to the twenty-seventh. It makes within a few pages half his vast work.

PLINY sets out with a bold and singular principle, that Vegetables have a Soul. What the more reserved THEOPHRASTUS called the PRINCIPLE OF LIFE in Plants, the Roman dignifies with that superior name; distinguishing it, however, from the soul of animals, as of a subordinate kind. We must not wonder at this thought in PLINY, for Soul with him meant less than we are taught to understand of it: he considers Soul as the Seat of Life; and tho' he had been taught by that HIPPARCHUS, whom all ages celebrate, to account the Soul of Man a part of the Heavenly Essence, yet he despises those who held, as he expresses it, the vain and idle thought, that it existed after death. We know hence what he means, by that he calls the Soul of Plants, a subtle something upon which their growth depends; and which perishing with them, there ceases utterly. This is all the addition PLINY made, if it may be called an addition, to the Philosophy of Plants.

IN his arrangement of the subjects, he adopts the received division of Vegetables, into Trees, Shrubs, and Plants, beginning with the Trees; but he is very vague in his subordinate distinctions. As there is nothing philosophic in his manner, the matter on which he seems to bestow most attention, is rather historical than botanic: the periods when foreign Trees were first introduced into Italy, and the inventors, or times of the invention, of cutting them into various forms for gardens, are his first considerations: from these he enters on the foreign Trees which produce Drugs and Spices; but he acquits himself in this part with so little knowledge, that he first says, the Pepper grows on a Tree like the Juniper; and afterwards, in the same chapter, that it is a small Shrub like the Myrtle: quoting their accounts who, as he says, had raised it at that time in Italy. Of Sugar he knew somewhat more; and we find by him, that the Romans had it from INDIA and ARABIA; he describes it as a honey-like concretion from a Reed. In the rest of the twelfth book, there is a great deal of information, concerning the early History of Drugs, but intermixed with abundance of absurdity and error. He only can gather knowledge from it, who first very well understands the subject.

HIS next book, in its first chapters, treats professedly of Unguents; and is historical, but not correct. After these the Palm, and many other trees, are treated as in the preceding part, so wildly, that Paper coming into consideration, leads him to an history of the books of Numa. The fourteenth book contains his account of Fruit Trees. He introduces this with some very whimsical censures upon VIRGIL, whom he reckons happy to have escaped those of the world. A great deal may be learned from what he has recorded of the old management of the Vine, and the various kinds of Wine; tho' we neglect the Arabian kind, which made barren women fruitful, or that Træzænian liquor which rendered the men impotent. The fifteenth book pursues the subject of the former; treating of other Fruit Trees: but that succeeding, is less regular. The honorary use of Leaves in Crowns and Garlands, has its place there; and after this, many of the Fruit Trees are treated of distinctly, and with great erudition. There are in this book also some approaches towards the Vegetable Philosophy. We see whence this part was collected; but it is not a subject on which PLINY succeeds happily. The next treats of the Culture of Trees; and of Manures, and the general Dressing of Land. The directions of THEOPHRASTUS are transferred hither: and a great deal is added to them. The articles of Grafting, and the rest of the Gardener's arts, are not set down in all parts so clearly as might have been wished; but we find the
Romans

Romans knew them thoroughly. There are passages, in this author, on the subject, from which we may even now gather much instruction. The Vine also is here considered farther than in the former articles, and with a great deal of knowledge. The eighteenth, nineteenth, and twentieth books, contain the practice of the Greeks and Romans in common Gardening and Agriculture: and in the end of the last of these there is introduced also something medicinal. The subject of his next book is of Flowers; and as they yield honey, the management of Bees is introduced among them. The twenty second treats of a mixed multitude of Herbs, and a second time of Honey; and the two next, give the medicinal virtues of many Trees and Plants, chiefly from DIOSCORIDES. The twenty fifth book sets out with what would have been a more regular Exordium for the whole, a kind of History of Botany: the rest of this, as also the succeeding Book, give the medicinal virtues of several more Plants, with some farther slight account of them. Finally, the last, or twenty seventh, tho' less methodical than all the rest, is full of useful matter; but this is strangely mixed with impertinence, and perplexed with error. Whatever the author's collections contained, that could not easily be brought into the other books, seems to be thrown together, without order, in this: and so concludes his Botany. By this sketch of the writings of PLINY on the subject of Plants, it will appear that they consist of a disorderly, and ill ranged collection of various things, compiled from different authors: and it will be found, these too often contradicted one another. PLINY, who put down all, is therefore said to have been sometimes at variance with himself; probably he never gave the last finishing to his work: we know an unexpected death surprized him. But while we regret the imperfections and confusion of this vast compilation, which he has left behind him, we cannot but allow its use and value.

THE Fate of Botany in this period resembles that in the preceding: Medicine was improved by the addition of a great number of Drugs; but the science, from whose stores these were furnished, languished. The History of Botanical Writers, is a common subject: GESNER is eminent in it, and FUECHSIUS, from whom the careful TOURNEFORT has compiled his just and judicious account, deserves more, perhaps, of the world, as an Historian than a Botanist. One could not wish to follow better leaders. But the immediate subject here, is not a history of the authors, but of the science: the two considerations are intimately connected: and this most essential part has been the least regarded. It can only be traced thus in their works.

C H A P. V.

Of the STATE of BOTANY, from PLINY to the Time of the ARABIANS.

THE Romans had been waked to a sense of the importance of a knowledge of Plants by DIOSCORIDES; tho' the Greeks, celebrated as they were in all other arts, had not caught from their own THEOPHRASTUS the sacred fire of science. That curious subject, the Philosophy of Plants, had lain neglected all this period, and was to lie in that dead state much longer; but from the time of PLINY, Plants, so far as they concerned medicine, or the useful arts, became greatly regarded. RUFUS wrote of them in this light under TRAJAN; and after him PALLADIUS became eminent in the whole art of Agriculture: so far as Plants were concerned within the limits of this subject, he treated of them, but no farther. The Romans extended the uses of Herbs, but the science of Botany was more known in early Greece. About a hundred and fifty years after CHRIST, GALEN appeared upon the theatre of the world; a Greek, as DIOSCORIDES, tho' under the Roman empire. He has been celebrated highly; and tho' perhaps, he deserves less than some have said, his merit, the value of his writings, is considerable. An attention to the history of drugs, possessed him even to enthusiasm: not content with what he saw of them, or what he heard or read concerning their history, he visited the places whence they came; Lemnos, for its earth; and Palestine, to see the Opobalsamum.

PLANTS, which make so considerable a part of the Materia Medica, shared his attention in a just proportion; but still it was as a Physician that he considered them; not as a Botanist. He seems to have been acquainted with about five hundred. Their virtues were the object of his search: and these he has charactered according to certain degrees of their imagined general qualities, hot, cold, moist, dry, and the like.

GALEN does not appear to have attended to the improvement of Botany, or if he had, the task had been too great for him. The science, which had rose with THEOPHRASTUS, continued to decline, and was now sinking fast into barbarism. A confusion of names, and ill conceived descriptions, obscured the little light which had once shone upon the subject; and all tended fast to general ignorance. PLINY had condemned the use
of

of Figures of Plants; and GALEN laughs at those who should think to learn a knowledge of them from descriptions. Such as wished to know their forms, were told there was no way but by their being shewn to them: and thus Botany, even by the authority of those who had most credit with the world, became reduced, from a regular and noble science, to a pitiful and precarious art; which men were to learn by rote from one another. This, tho' they did not seem to see so much who proposed it, struck at the root even of its utility: for it was in vain, the ancients informed men of the virtues of Plants, if their names were changed. This GALEN should have foreseen must happen, when the knowledge of them was taught in so precarious a manner; and it had already happened: for GALEN did not know many of the Plants of THEOPHRASTUS; nor did these verbal instructors, such as they were, well understand one another. This at once shews the misery of a neglect of science; and places in a light of just regard, the modern fixed and eternally established distinctions.

ORIBASIVS followed GALEN; his countryman, and long his disciple: we find in him an instance of the unhappy truth just named; and we find little more. GALEN knew scarce half the Plants of PLINY, and ORIBASIVS did not know those of GALEN. Error is always the Parent of more error. All that is useful in this author, he had from GALEN; but he has debased the study with puerile imaginations.

AETIVS followed, or was cotemporary rather with the latter years of ORIBASIVS, another Asiatic Greek, as he and GALEN were. He was a mere compiler, and a very indifferent one, so far as Botany, our subject, is concerned. TRALLIAN came next; and he disclosed a spirit more free and fit for science. He studied things themselves, not the descriptions of them; and he often differs from GALEN, where truth demanded it, tho' he allows that author the high epithet of Divine. It was happy for the age, that such a man arose as a Physician; and it had been well for Botany, if a genius so much of the original stamp, had directed his thoughts more that way; but it was then, and it continued long after, an unrepented science.

ANOTHER Asiatic, ÆGINETA, arose a little after; a physician and a scholar, who must be named, because he treated of Plants, but not distinguished by the title of Botanist. He made an abridgment of the works of GALEN and his first followers. In this work he could not omit to name many Plants; but he added nothing to the store.

SUCH

SUCH is the History of Botany during the empire of the Romans. The rudiments of the science were imported from Old Greece ; but tho' Greeks wrote afterward, these were very little extended.

PERIOD THE THIRD.

The State of BOTANY among the ARABIANS.

C H A P. VI.

The Revival of the SCIENCE under the CALIPHS.

THAT knowledge of the Vegetable World, which Egypt learned from the Chaldæans, and which being received in early Greece, was there exalted to a science, declined during the Roman empire, and died with it. That people had neglected it extremely ; and tho' many Greeks, celebrated for their knowledge, wrote under their government, the best they did was copying their masters. We now must view the science in another Æra. After a period of more than three hundred years, wherein this and all other learned arts lay utterly uncultivated, Botany revived among the Arabs.

IN the year of CHRIST 754, the second Caliph, AL MANSUR, a philosopher and scholar, fired with the praise bestowed upon the Grecian knowledge, gave order that the most valuable of the writings of that people should be translated into his language. Something was done : but the great path he opened lay untrodden after him, till the seventh Caliph, AL MAMUNEM. This patron of the useful arts, applied with a new spirit to what AL MANSUR had so well begun : he sought from Greece, by embassies, whatever writings were most respected in their philosophy ; and science, in the year 832, took root among his people. He who had thus obtained the Grecian writings, invited next, by his liberalities, all the learned to join in an undertaking of translating them : peculiar names among these people, now grew eminent in medicine and in philosophy : each had his destined part in the great work ; and the Caliph himself,

self, from time to time, inspected their progress, and joined in their researches.

BOTANY now put on a better face; and promised more in this new region than any where, excepting in her native soil. Ages had passed since their days whose writings now became once more the basis of all knowledge; and much had been done, and much known, tho' rudely and irregularly hitherto, among the Arabians themselves. This they added to the stores they drew from the old Greece; and they became adopters and improvers of Botanic Knowledge: not content to be what the late Greeks had been, mere slaves and copyists of their predecessors. These Arabs were an intermediate race between the Greek and Roman states, and ours; and it is, indeed, to them Europe owes, much more than to any others, its present knowledge of medicine.

SERAPIO, the first in point of time, perhaps also the first in genius, among the Arabs, lived in the days of that second Caliph who undertook the introduction of the Grecian arts among his people: perhaps it is to this writer we owe the attention which that Caliph shewed to them. He collected whatever he could find relating to medicine, among the authors either of Greece or his country, reduced all to order, and enriched the compilation with much knowledge of his own. He knew several of the Greek Plants well; and ascertaining the before vague and uncertain meaning of their names, made thus the first advance among the Arabs, toward the improvement of Botanic Knowledge.

RAZIS appears considerable after SERAPIO, and he had opportunities to have done much more than the other. SERAPIO lived before and during the time of the first attempt to introduce the Grecian learning into his country; but RAZIS followed after almost two centuries, within which period that seventh Caliph had appeared, who perfected the work the second had begun; and when all the Grecian knowledge had been almost a hundred years familiar in his country. That part of the *Materia Medica* which is obtained from Plants, led RAZIS to speak upon this subject; but it makes only a small article of his works; and all we learn from it is, that tho' Botany had continued advancing, rather than declining, from SERAPIO's time to his, it yet had received but little addition.

DIOSCORIDES and GALEN were the oracles of the succeeding AVICENNA; but he added also something from the improvements of his countrymen; and some portion of knowledge, tho' still less, from his own. He seems to have known many Plants; and it must not be denied, that something is added to the Botany of his country, tho' it be not much, in

his writings. ACTUARIUS appeared soon after, an author of a new kind : a translator of the Arabian knowledge into its fundamental Greek. Such changes science knows, and such strange journeys. The character of ACTUARIUS is formed of learning, diligence, and modesty. He selected from the earlier Greeks, as well as the Arabians, and from the whole formed a judicious body of medicine ; in which the *Materia Medica*, and Plants, as a part of it, have their place : but if he has added any thing on this head, it is less than his predecessors. MESUE, a prince, next applied himself to the study of medicine among this people. He lived about the middle of the twelfth century ; and to a very perfect knowledge of the former writers, added many things, from an extensive and well considered experience. AVERRHoes was cotemporary with MESUE ; and, like the rest, he compiled with care, and added his own knowledge. GALEN was his oracle concerning the virtues of Plants ; but he seems also to have known them from his own observation.

EBENBITAR, a more distinguished name than all the rest, followed these in the beginning of the thirteenth century ; and closed the Arabian catalogue. He studied the whole *Materia Medica*, but was distinguished most for Botany ; and he not only increased the knowledge of it greatly, but gave the science itself a new and more respected estimation. He travelled, as GALEN had done, to obtain perfect knowledge ; and he wrote down at large his observations and discoveries. As the Botanic part of the *Materia Medica*, had employed his greatest attention, and he had seen the Plants themselves, in long and repeated journies, and as he speaks of them from what he saw, his writings have a merit beyond those of all his countrymen. He at the same time extended and ascertained the objects of the science : from him may be known the Plants, not of the Arabians only, but many of those of the old Greeks : which we trace elsewhere in vain.

PERIOD THE FOURTH.

The State of BOTANY during the BARBAROUS AGES.

C H A P. VII.

The DECLINE of BOTANY to an absolute NEGLECT.

WITH EBENBITAR died the Arabian knowledge; and Barbarism overspread the world: this and the other sciences lay for a long time neglected. This Period takes its date from the latter end of the twelfth century; and it continued till the time but little earlier than our latest ancestors. Books were no longer written on any part of Medicine; and the entire art now, like Botany in a somewhat earlier time, depending on tradition, gradually decayed. But it was fated, that this science, as it had its origin in Greece, should yet owe also to the Greeks of this period a faint attempt towards its restoration. The first Botanic writer who appears after the just celebrated Arabians, is MYREPSUS. He wrote when every thing was yet obscured in clouds of ignorance, and appears himself with difficulty, emerging from the general barbarism. His language is inelegant, and full of strange terms; and his knowledge of Plants is extremely confused, not to say very imperfect. This dawn of a reviving science was afterwards clouded over, and a more perfect neglect followed. The next writer of these Greeks, NICOLAUS PRÆPOSITUS, is much inferior in all respects to MYREPSUS; he is a crude collector, with plainly nothing of his own. The next in order of time to him is HILDEGARDIS, and he sinks yet below PRÆPOSITUS, degrading the little knowledge he appears to have collected, by puerilities, and superstitious folly. Soon after this slight author appeared PLATEARIUS, with something more of study and design. This writer opened the fourteenth century; and gave some promise of a reviving literature. His distinction of the Vegetable part of the Materia Medica, is upon the received plan of Tree, Shrub, and Plant, and he writes with some knowledge of the subjects: poor in comparison with those

of a much earlier date; but superior by many degrees to his immediate predecessors. Twenty years after PLATEARIUS, SYLVATICUS published a great work on medicine; but he had undertaken more than he could perform; and with a design of explaining terms, he rendered them more obscure. SYLVATICUS lived about the year 1320, and he appears to have known little of Plants. The same period furnished three other writers scarce better than the last: these were VILLA NOVA, DONDIS, and PETER CRESCENTIENSIS. This latter wrote expressly upon Plants thro' a great part of his treatise, but with a degree of ignorance scarce to be equalled. The miserable state of literature continued; yet men wrote, and wrote of Plants. More than a hundred years after these strange authors, CUBA published his HORTUS SANITATIS, in 1486; and he was followed by THERTONA, DE BOSCO and SUARDUS. The last of these wrote his Antidotarium in 1526: the others their several pieces somewhat earlier: all spoke of Plants, but with most perfect ignorance; nor had they language worthy even of their poor conceptions. The writers of an earlier time, to whom they referred, were some of the latest Arabians: as to the Greeks, they did not so much as properly know their names. They shew they could not spell HIPPOCRATES.

PERIOD THE FIFTH.

The STATE of BOTANY at the New DAWN of LITERATURE.

THUS, for four centuries, Barbarism overspread the world; from the days of EBENBITAR, the last of the Arabians, to the latter end of the fifteenth century. Then dawned upon the world the first light of a revival of letters: and Botany was early regarded by those who shine most conspicuous in that undertaking. It is singular, that in this science we owe all to Greece: there the first rudiments of Botany were established; and that GAZA was a Greek, who in a manner began the restoration of learning at this period, by a translation, first of ARISTOTLE, and then of THEOPHRASTUS, into Latin. This led the way; and the father of the science had afterwards so many commentators, that Botany was plainly a much esteemed science. The works of this great author, as they had been the original, became now the second basis of all Botany; and SCALIGER
and

and CONSTANTINE, HEINSIUS and BODÆUS A STAPEL, laboured to explain his meaning. There wanted, and there yet wants, a Botanical Translator, to shew us all his merit, and to give new improvement to the science. HERMOLAUS BARBARUS followed: no more indeed than a Commentator, but one of a superior excellence; and these were the men the age then wanted. It was not likely science should shew her long obscured head at once in an original form: the rudiments were first to be traced in these early masters; and HERMOLAUS explained excellently, the accounts of DIOSCORIDES, relating to the Botanical part of the *Materia Medica*. The beginning of the sixteenth century gave the world RUELLIUS, a Botanist and a Scholar; who following these with a greater degree of knowledge, and scarce less learning, established finally the doctrines which they had just begun to raise. Botany began with him to wear the face of a new science. Others had studied names, and words; RUELLIUS things: he was skilled in Plants, and for the time very considerably: he therefore was able to execute what others had attempted vainly; and he told the world what were the Plants then known, which answered to the names in DIOSCORIDES and THEOPHRASTUS. From him first, since this revival of letters, men knew what were the Plants mentioned by the ancients; and he is the first who for very many ages had done any thing towards the advancement of the science of Botany.

THIS opened a path into which many followed; and from RUELLIUS we may justly date the *Æra* of Reviving Botany. MARCELLUS VIRGILIUS came next after him, a lover of Botany, tho' of no great knowledge; faithful in his comments on the old Greeks, and happy in the application of much of RUELLIUS's knowledge. In some places he has interpreted DIOSCORIDES differently from that author, and always in that case unhappily. MONARDUS followed him; and while he added a great deal from his own studies, he did justice always to RUELLIUS against this inferior, tho' useful writer. A number of interpreters now followed; LEONICENUS BRASSAVOLUS, BRUNFELSIUS, RIFFUS, the two CORDUS's, and GOUPYLUS. FUCHSIUS come after these, and more than all men turned his mind to original and additional knowledge: the old Botany had been enough studied; and it was time now to look into the book of nature. LONICERUS had shewn many errors in the interpreters of PLINY; and BRASSAVOLUS had attempted boldly, tho' with too weak abilities, at something new. BRUNFELSIUS took the same path; and tho' he added something, succeeded, upon the whole, but unhappily. These, however, all followed the Ruellian course; and something, from time to time, was added

added to the science. The first *CORDUS* spoke also of some Plants from his own knowledge; and the second of that name, son to this first, besides his comments upon *DIOSCORIDES*, published *A HISTORY OF PLANTS*, with Figures. He was careful in his observations, and his descriptions are scarce otherwise imperfect, than from the want of terms, for the distinct parts; an imperfection not to be charged upon him, so much as on the state of the science in his time.

RIFFUS, who wrote a little before, and *AMATUS LUSITANUS*, who followed this *CORDUS*, were rash and ignorant commentators on the ancients; presuming to explain what they did not understand. *LACUNA* had more learning, but not much Botany. *TRAGUS*, who appeared next after these, and flourished about the middle of the sixteenth century, was a proper successor of the last *CORDUS*: he studied Vegetables in their own structure, not in books alone. He published a history of Plants, with tolerable figures; and he has given great light into the *GERMAN FLORA*. *CORNARIUS* lived in the same time, and he made some, tho' slight additions to the science. He is most known by a dispute with *FUCHSIUS*, too potent an antagonist. *GOUPYLUS* was a scholar, and a good commentator; but he added little, tho' he explained much: a useful, rather than a great writer. *FUCHSIUS* a little after published an excellent account of the German Plants, with a great many good figures: but *DIOSCORIDES* is too often the author of the descriptions; and they are frequently, therefore, unlike the Plants: for the time is not yet come, when the Greek Botany is so easily reconciled to what we see in Europe. This *FUCHSIUS* wished to find; and therefore often persuaded himself he really found it.

RONDELETIUS, about the same time, travelled in the same path with advantage. He was happy in an associate, *PELLICERIUS*, a dignified churchman; to whom those who envied *RONDELETIUS*, attributed his discoveries. He was a Naturalist of great diligence, and understood very well what had been done before him. *PLINY'S* Plants never were so justly understood as by his means; tho' in the nature of the subject, there must be great imperfection. About this time also, near the middle of the sixteenth century, England produced a kind of Botanist. *TURNER'S HERBAL* was published in 1551: a work better spoken of by foreigners than it deserves: but its early date gives it some claim to notice. *MATHIOLUS*, celebrated for his laborious commentaries on *DIOSCORIDES*, flourished a little after these. He had great advantages from the many excellent writers who had considered that author before him; but he wanted a real knowledge
of

of Plants. He has collected boldly, and transcribed hastily, upon this subject: something of this he owns; but more is true. MARANTA, and ADAM LONICERUS, are also to be added to the Botanists of this great period; the first knew Plants well, and has explained happily some of the obscure ones of the ancients; the other was too much obliged to TRAGUS.

BOTANY was become so respected, and so fashionable, at this happy period, that some began to imitate those venerable Greeks who undertook the longest voyages, in search of Plants; and others, whom their peculiar occasions called abroad, made this also a part of their employment. The new world, AMERICA, was discovered; and GARCIAS, and the two ACOSTAS, HERNANDES, and MONARDES, BONTIUS, PISO, and MARCGRAVE, with many more, brought from thence, and from the other remote quarters of the earth, a multitude of new Plants. The stores increased, new species were known, and the study was more cultivated: but yet figures, descriptions, histories of the peculiar Plants, were all; and nothing was attempted in the road of Science.

DALESCHAMP appeared about the same time with these, and studied the Vegetables of France carefully. He undertook a General History of Plants; and MOLINÆUS assisting, there appeared, after some years, that great work the HISTORIA LUGDUNENSIS: valuable, tho' too full of errors. TABERNAMONTANUS was nearly of the same time; a curious observer of the forms of Plants, and of their virtues: but he took so much from others, that it is hard at this time to say what was his own. DODONÆUS had written also just before this period, adding some Plants to the already increased number; a writer much obliged to others, but fair in owning it: and from a translation of his works, by Doctor PRIEST, our GERARD put together his English Herbal. In this, however much he borrowed, he added fourteen Plants to the Botanic Catalogue.

CAMERARIUS was another of the Botanists of this period, happy in his intimacies and connections with eminent persons, who studied the same subjects. He was attentive also himself to the living Plants; and the world would have been much indebted to him, if all he wrote, and all he collected, had been published. SARRACEN, after him, gave new lights into many parts of DIOSCORIDES; a task the easier, because more Plants were known: but his error, like that of all his predecessors, is the attempting too hardily to reconcile the descriptions of those old Greeks to the Plants of our Europe. BELLONIUS must be added to the long list of Botanists of the period whereof we now write; an author who seems only to have

wanted longer life, to have demanded by his writings immortality: assiduous himself, and urging others to assiduity. What he has written of Plants, shews a discerning spirit, and an enterprizing genius.

IN 1573, RAWWOLF travelled the East, in search of knowledge; and tho' his observations were distracted by many other objects, he yet brought in great additions to the store of Botany. GUILANDINUS and PROSPER ALPINUS followed, professors in the Patavian Garden; they added to the increase, as well as amended the state of Botany of their time: the latter visited Egypt in 1580, and brought home many new Plants. The love of the study now grew universal: and the immediately succeeding time gave birth to system, in the breast of CÆSALPINUS; from whom we are to date a new *Æra* in the Botanic History.

PERIOD THE SIXTH.

The REVIVAL of the SCIENCE.

C H A P. VIII.

Of the ORIGIN of SYSTEMATICK BOTANY.

THE term BOTANY, has been understood as expressing the Doctrine of Plants at large, and in all its various lights; but tracing the origin and progress of the study, we see it at the several periods under distinct appearances: these, however, are all reducible to those general heads, which we may distinguish by the terms PHILOSOPHICK, HISTORICAL, and SYSTEMATICK BOTANY. Of these, the first and noblest has been the least cultivated: it began, and in a manner ended, with THEOPHRASTUS: its object is the nature of Vegetables as Vegetables, independent of all other considerations. To this succeeded the HISTORICAL BRANCH; gathering the Names and Numbers of Plants, their Place of Growth, their Virtues, and their æconomic uses. This was the object of those who studied Herbs from THEOPHRASTUS, to the latter end of the sixteenth century; when CÆSALPINUS gave origin to the SYSTEMATICK BOTANY. Till his time Plants were arranged, even in those who wrote best of them, accord-

ing to the old and irregular division into TREES, SHRUBS, and HERBS; or according to their virtues, to the letters of the alphabet which began their names, or by such other vague and arbitrary methods. Their increased number now made it necessary they should be better arranged; and this great author struck out that path which has since been trod so happily, of examining their parts, and deducing thence the characters of Classes: arranging in each class all those which had the peculiar mark which made its distinction. This is the true and only road to certain knowledge; we are happy who see it so assiduously followed, and so greatly improved; but the praise we owe to those who have given the Systems of Botany their present form, must not make us forget his glory to whom they owe their first establishment.

THE origin of systematical Distribution, was the selecting some part of a Plant which was obvious and regular in itself; and establishing a Character upon its Description, to which all others, that had the same mark, were referred.

THUS were formed the Characters of Classes, first; and then the distinctive Marks of Genera. Between these also there came naturally, from lesser particularities, the Subdivisions of the Class, by Orders. The path once opened, one would have thought, all who had judgment, would have rushed into it: but this did not happen. The European Founder of the science was more than a century without one follower. It was evident no other way could ascertain the objects of the study; yet this was long rejected.

THE original invention was the choice of some one part for the Character: and what part that should be, was left at discretion. The great Inventor chose the Seeds: which he had studied carefully; he arranged Plants according to the situation of the Corculum, or Heart of the Seed, and to its place upon the Plant: and upon this basis he founded the first just arrangement of Plants.

TRUTH was thus shewn; and at length, when the great author's name was almost forgotten, others adopted it. None doubted whether CÆSALPINUS had done right in selecting some part, from which to form a Character; but it became a question whether he had chosen the most proper. Hence followed the variety of methods: and the new period became a fruitful in systematick, as that of about one hundred and thirty years before had been in the historic writers. Conviction at length appeared upon the face of the design; and every Botanist pursued it: various parts of Plants, and various collections of parts, were adopted for the Characters

of Classes: opinion led some, and a desire of novelty induced others, in their choice of different portions of the Plant. Tho' many bad systems were thus formed, there also appeared several which had merit; and not the worst but gave a great deal of new light into the structure of that part on which it was established.

THE old distinctions were no more regarded: the virtues of the Plants, the seasons of their flowering, their place of growth, or the initial letters of their names, were no longer made the objects of arrangement. The early division into Trees, Shrubs, and Plants, indeed, long held its place: and stubborn Nature so far triumphed over the distinctions of arbitrary science: at length LINNÆUS rose to abolish that.

To trace the period, and the history of this new form of the Botanic Study, is to do more honour to this CÆSALPINUS: we see him rise alone from the full crowd of those who thought it was enough to number and describe the Plants; and tho' the improvement he proposed was evident to all the world, yet for so long a space of time none followed him. He appeared single; and tho' respected, was unimitated. There was danger his discoveries would perish with his name. But tho' we must give the invention of system to a stranger, our countrymen revived it after this neglect. One hundred and three years after CÆSALPINUS, MORISON, a Briton, entered earnestly, and not unhappily, into the same path. RAY followed, whom an accidental service to a friend, led into the full road of science: our bishop WILKINS, then busied in his *REAL CHARACTER*, desired of RAY an arrangement of the Vegetable World, suited to the purpose of that work. This first directed the mind of that great man, seriously and attentively to the classing and arranging of Plants; a study to which he afterwards devoted himself in a manner entirely; to the great benefit of the Botanic World. He formed a method which, tho' full of imperfections, yet comes nearer nature than, perhaps, any other. KNAUTIUS followed RAY, and HERMAN him: RIVERIUS was cotemporary with KNAUTIUS; these both wrote in the year 1690. And after four years more followed TOURNEFORT, the greatest of them all.

THUS closed upon the science the seventeenth century; in the last seventeen years of which, the long neglected institution of CÆSALPINUS was so well revived, that there appeared no less than six distinct Systems of Plants; and each of very considerable merit. The authors of the four first held the Fruits and Seeds, according to the original practice of their great master, to be the properest, at least the most essential, parts on which to found a System. RIVERIUS struck out the design of fixing the Cha-

acters

ractions in the Flower; and TOURNEFORT pursued this with an attention, industry, and truth, which did honour to the Sovereign under whose patronage he wrote.

BOERHAAVE opened the eighteenth century: a name, which if it did not shine with greater lustre in the other sciences, would be eminent in Botany. RAY yet lived, and continued his useful labours, adopting more and more parts of Plants to his distinctions. BOERHAAVE continued the system in its original course, making the Fruits and Seeds of Plants his great objects in their arrangement.

IN 1711, HEUCHER of Wittenberg appeared with credit; and led in a long train, who less regarding the original object of distinction, followed RIVIERUS and TOURNEFORT in the choice of the Flower. Seven years after RUPPIUS wrote, adopting the same part as the foundation of his system; and this continued the established doctrine with PONTERA, HEBENSTRET, and LUDWIG.

IN the mean time MAGNOL distinguished himself by a new System, formed upon the Construction of the Cup; and in the year 1735 LINNÆUS, too great for praise, after having unsuccessfully proposed his new thoughts in England, published in Holland that System of Plants which characterizes the Classes according to the Filaments and Style; and takes into the General Distinctions all the Flower. This system the succeeding four and twenty years have more and more established; and if we may conjecture from its value, it will live (even when a natural method shall be found) so long as there is science.

THE END OF THE FIRST BOOK.

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

1950-1951

PHYSICS 101

LECTURE NOTES

BY

ROBERT A. SERBER

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B O O K II.

O F T H E

VEGETABLE STRUCTURE;

A N D T H E

L I F E O F P L A N T S.

I N T R O D U C T I O N.

WE have seen the Progress of Botany, and the Rise of Systems ; and there will be a place to examine each : to shew its merit and defects ; and to enquire how far these may be serviceable to the establishing that great article A NATURAL ARRANGEMENT OF PLANTS : for all hitherto are merely artificial.

To advance by regular steps towards this great object, we are first to enquire what Vegetables truly and distinctly are ; what place they hold in the general arrangement of natural bodies, and by what distinctive Characters they claim that separate department ; of what substance they are composed, and what is their internal structure ; what portion or degree of Life it is which they enjoy : and lastly, what those exterior parts are, and whence deduced,

ced, on which these artificial systems have been, and on which a natural method may be established.

WITH this knowledge of the subject in general, and of its particular divisions, we may be able to judge how much is natural in every system, and how much imaginary; what is the true advance each author has made; and how far his discoveries or conceptions may be assistant in the point desired. The Vegetable Construction, and the dependant Life of Plants, will be the subjects of the present Book. This is properly the Philosophy of Plants, extending to all ranks and orders of the Vegetable System. The exterior parts vary in different subjects; but yet they are in all an established, and that a very limited number. These will be the subjects of the succeeding division: and as all Systems are established upon these; and all arrangements, and all distinctions of them, from Class to Species, have their foundation in the difference of those parts; when they are explained, and not before, the Distinctions, Characters, and Names in Botany may be understood.

C H A P. I.

The PLACE of VEGETABLES in the SYSTEM of NATURE.

VEGETABLES, the knowledge of which is BOTANY, hold a middle rank in the great orders of the Creation. Natural bodies are arranged into three classes, distinguished easily, and utterly distinct from one another: these we call MINERALS, VEGETABLES, and ANIMALS. The general study of all is NATURAL PHILOSOPHY; and the particular detail constitutes NATURAL HISTORY. BOTANY regards only the Vegetable Class; but it comprehends so far, both doctrines; extending to the Philosophy as well as the History of Plants.

To enter properly upon the study, we are first to ascertain its objects, in distinction from those of the other two great Classes. The out-lines of the distinction are these. Minerals have increase without life, organized parts, regular growth, or sensation; Vegetables have a regular growth, and a degree of life, but no sensation; Animals grow, live, and feel. Minerals have no vessels; Vegetables have vessels for their nutritive juices; Animals have nutritive vessels and nerves; these last are a peculiar and distinct system. On this construction depends the essential, universal, and invariable difference of the three great classes of material beings. Minerals wanting vessels, tho' they may be increased by an addition of parts, cannot have a regular

regular growth; for that must depend on vessels. Plants having vessels, may have a regular growth; for it is the effect of their proper office: but wanting nerves, they cannot feel; that being the quality of nerve alone. Animals which have nutritive vessels and nerves, grow and feel; these being the offices of those two systems.

THIS establishment of the characteristick of Animals in a system of nerves will appear singular; for every opinion does so when it is first proposed: but, probably, more observation will the more confirm it: all I have been able to observe, has this plain tendency; and certainly there wants such a fixed mark for the separate character. Nature made the mineral, vegetable, and animal world distinct; and nothing is distinct except it have some such invariable character of the distinction: this has been unluckily traced hitherto, and even the greatest naturalists have endeavoured to find it in characters that were equivocal: many minerals have a regular form; and there are Plants which are not fixed to one place; and animals which are: yet these have been the usual marks of separation. Anatomy teaches us distinctly what the nerves are; and by that system we separate the two greater classes: the minerals are sufficiently distinguished from both, in their nature and obvious appearance. Nature makes all her changes by minute gradations, nor is there any great gap in the universal chain. Thus the Sensitive Plant approaches towards the animal kind, in motion; and the Dusty Byssus scarce enjoys an apparent distinction from the earth on which it grows: yet with a fixed character once established, there can be no difficulty or confusion.

VEGETABLES are placed by Nature in a middle state, between the mineral and the animal classes: superior to the minerals, in having organized bodies; inferior to the animal kinds, in wanting a nervous system. They are capable of growth, but below sensation.

C H A P. II.

Of the CONSTITUENT MATTER of VEGETABLES.

WE are accustomed to consider the Matter of Vegetable and Animal Bodies as distinct; but all may be reduced by fermentation to the same substance. This fermentation is a plain and regular operation of nature; which always takes place, in vegetable and animal bodies, when they cease to live and grow; and needs no human art to help it. A piece of the

the flesh of a dead Animal, and the bruised stalk of a Plant, left to themselves, destroy themselves thus by their own power. They grow moist, they heat, they dissolve into one soft offensive mass; and there is no knowing from any quality in that matter, which was of animal, or which was of vegetable origin. The animal and the vegetable nature are lost utterly; and each of the bodies is reduced to a substance neither animal nor vegetable in its nature, but capable of being converted into either; of feeding equally Animals or Plants. So true it is, that Matter, as Matter, has no concern in the qualities of bodies; but all depends on its arrangement: hence water, which is tasteless, feeds aromattick Mint; and the same earth gives nourishment to bread and poison. This solves the problem, of the same earth yielding innocent and hurtful Plants: and it is no common pleasure to observe, that the doctrines of our celebrated NEWTON are never shaken by true experiment; but the more strictly we examine nature, the more they are confirmed.

It is not the matter which originally constitutes a Plant, that makes it acrid or bitter, esculent or poisonous; for Matter, as Matter, is all alike: the qualities of Vegetables depend upon the arrangement of those common particles; and this arrangement being made by the vessels of the Plant, it must be different where they are differently constructed. What those vessels are, and how they are disposed in various Plants, will be our next subject; but thus much we may see upon the slightest view of Vegetable Nature; that the construction of various kinds is extremely different; and that this variation of form is owing plainly to the construction and disposition of their vessels: and as we find their qualities differ as much as their forms, and are, in some degree, connected with them, we need not look further for the cause. As we advance in this plain path, we find the traces of that truth marked yet more strongly: the difference of Plants from Plants, is not by a wide and important distinction between individual and individual throughout the whole system: the great and palpable characters of variation, belong not to single vegetable bodies, but are common to great numbers, in distinction from other numbers equally large. These constitute the natural classes of Plants; which, however undiscerning man may have confused or overlooked their characters, are really but few.

CERTAIN Plants have hollow, jointed stalks, and single narrow leaves, husky cups for the flowers, and single seeds in them. This character distinguishes not one Plant from all the rest, but one vast family, the Grasses, from all other families of Plants. In the same manner, others have flowers in round spreading tufts called umbells, and two naked seeds following each,

each, with five small filaments in every flower. These are the Umbelliferous Plants. The most minute parts of their flowers agree in this number, and this is again the character and distinction of another multitude of Plants; all of which agree in every particular of this construction; and differ by it from all others. Certain other Plants produce their seeds in little Pods, and have four of the small filaments which support the antheræ in their flowers longer than the others: slight as this mark appears, it is most constant. These are the Siliquose Plants: and this is, as the preceding, the character by which a large assortment of Herbs differ from another great assortment or class; not one from all the rest.

THERE can be no doubt, but the structure of the vessels of the Plants occasions this difference in their forms: for there is no other cause; and nothing is effected without one: but we see also, that these arrangements of Plants, as they are separated from all others by those characters, have also their peculiar and appropriated virtues; common among themselves, and distinguishing them from others. Thus, all the Grasses and Corns are esculent: the leaves are food for cattle; and the seeds for the human species, and for a variety of other animals. The Umbelliferous are warm and aromatick, and the Siliquose Plants are acrid and deobstruent. These observations hold generally true; and the same agreement of virtues in those Plants which have the same characters of distinction, will, I believe, be found throughout the whole Vegetable System, when a true natural method shall be established. This agreement of Plants of the same class in their virtues, has been observed by many; but the great and plain truth which it may teach, seems to have been overlooked entirely. It is allowed, that Plants have very distinct forms: it is allowed also, that this distinction of form depends solely on, and arises only from the different construction of their vessels: we find Plants which have a like construction of vessels, have like marks of distinction from them; and that they have the same virtues: does it not follow, that as the form common to so many, depends upon the peculiar construction of those Plants, so do their virtues; which those of the same form, that is of the same vascular construction, possess also in common?

THIS brings us to the Point whence we set out. The Matter which composes Plants is the same in all the kinds: it is arranged into as many forms as God created Species in the beginning of things; to which there has not been one addition since, nor one lost from the number: according to the arrangement of this common Matter, it acquires peculiar qualities

and virtues; the Matter being susceptible of any form, and from that form deriving all those qualities.

WE know what things they are which feed and form a Plant; and we know these are the same in all the kinds. One parcel of mould will produce every species; one quantity of water moisten that earth for all; and they all grow surrounded by one atmosphere. We may eat this mould without hurt, we drink this water, and we breathe this air. Yet from a seed of Deadly Nightshade sown in this, rises a leaf, a dram of which is poison. The burning juice of Spurge, or the bitter of Gentian, are neither in the earth, the air, or water: these are composed of matter suited equally to the formation of all bodies; and ready to form any into which they are thrown; this matter is inert in itself, and possesses no quality but its own firmness. The vessels of the Plants arrange it differently; not only in different species, but in the distinct vessels of the same Herb; and this arrangement gives to the common matter scent and taste, colour and virtue. Do we need more proof that it is the form into which matter is thrown, which gives bodies all their qualities? Let us observe the effects of those simple operations, which, under our own eye, put various subjects into different forms. In many minerals the substance itself is innocent; but lay it on the fire, and its vapour is poisonous. And in Vegetable Bodies, our immediate subject, the same substance often possesses, in succession by these changes, three distinct qualities; one while in the state of nature, a second while fermenting, and, after it has been fermented, another different altogether from both. We cannot doubt, but the matter which rises in vapour from the mineral, is the matter or substance of that mineral; and as we find it innocent in the one state, and fatal in the other, it cannot be but the different arrangement of the parts of the same matter, makes this great difference. The vapour of fermenting wine, rises from the innocent Grape; and neither that, nor air, nor water, have simply any fatal qualities. We find so many things can make this change in matter, that we need not wonder a construction so complex and delicate, as we shall presently see the vascular systems of Vegetables to be, can effect it. Plainly, the original particles of all matter are the same. The vegetable substance is composed of the same body with that of animals and minerals; and while the earth feeds Grass, the Grass an Ox, and the Ox a Lion, the proper and unaltered substance of matter passes alike thro' all; and is the same in all; tho' differently arranged in the several species. Spontaneous fermentation divests it, after all these changes, of the several forms and qualities it received from those various bodies, and retained while

in them; and being reduced by this natural operation to its first state, it is ready equally to feed, and fill, and compose one or the other of them. THALES, the Greek, said all was formed of water. He seems to mean, that all bodies are composed of one and the same matter, which is insipid, and void of every quality. This matter, he supposes, tho' composed of solid particles, to have been originally fluid; as that condition rendered it most easily susceptible of the various necessary arrangements. Solidity in these appeared to him a condition of restraint: and, perhaps, there was perfect truth in this philosophy.

C H A P. III.

Of the ARRANGEMENT of MATTER into a VEGETABLE BODY.

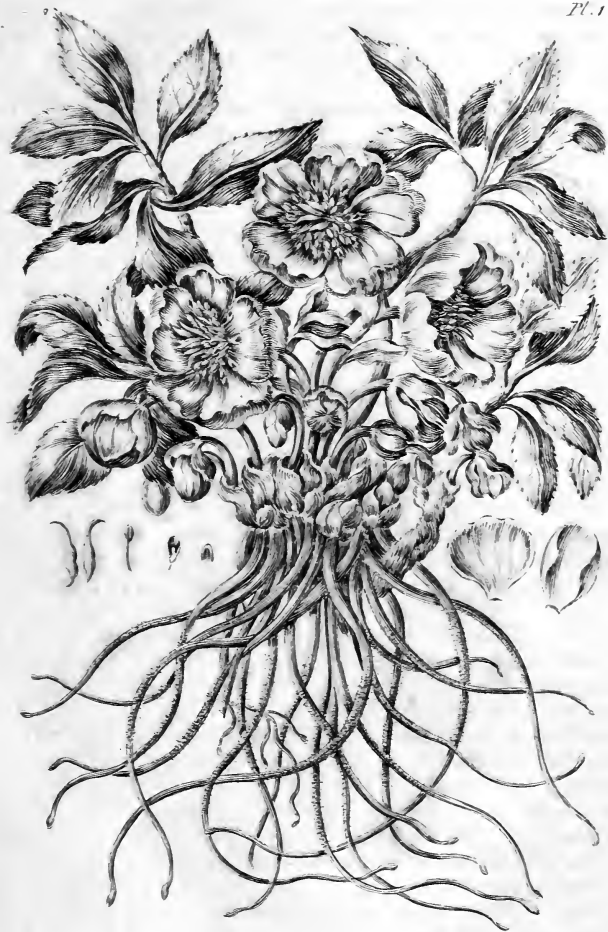
THE first view we take of a Vegetable, gives us an idea of an almost infinite number and variety of parts, different in form and structure; and we are led to consider it as complex in so high a degree, that the arrangement of matter for the forming all those parts, seems in every individual a new miracle. The ROOT, the STEM, the CUP, the PETALS of the Flower, the FILAMENTS, and the SEED VESSEL, are all distinct from one another in COLOUR, FORM, and OFFICE. Thus much appears of difference externally; and when we attempt the least article of a dissection, there arise new wonders, in the construction of each part, and its peculiar vessels. These are of one kind in the outer, and of another form and structure in the inner rind, still different from both in the internal parts, and full of new variety. The appearance has disheartened many from prosecuting the research, who might have made discoveries; for large draughts are needful of this spring, and they are, indeed, PIERIAN.

PERSEVERANCE in the examination, will divest the subject of all this seeming intricacy: the parts which appeared so numerous, will be reduced to a very small account; and the two sources of variety will be reduced to one.

A CAREFUL Maceration, in soft water, will separate the real parts from one another, and shew that many are but distinct in appearance. By dissolving the parenchymatous substance of entire Vegetables, we obtain the vascular parts, separate from one another, and entire: and whensoever we begin the account, we find them only seven. These are, 1. an

outer Bark; 2. an inner Rind; 3. a Blea; 4. a Fleſhy Subſtance; and 5. a Pith. There is, indeed, between the Fleſh and the Blea, 6. a Vaſcular Series; and 7. Cones of Veſſels take their courſe within the Fleſh: theſe are properly as diſtinct parts as the five more obvious ones, and theſe are all.

WHATEVER part of the Plant we examine, we find theſe, be it a Fibre, the Body of the Root, or the Stem. We never find more: and tracing theſe thus ſeparate from all other parts of the Plant, we ſee the other, or external portions, are only productions of them. All the imaginary complex ſtructure of the Plant beyond this, vaniſhes in an inſtant, like thoſe enchanted caſtles in romance, which when the talifman is broke, diſappear. The Root, its deſcending Fibre, and the aſcending Stalk, we thus find are one, and not three ſubſtances: the ſame ſeven parts compoſe them; and they are continued from the one to the other, or formed by the proceſs of growth. This reduces the entire Vegetable to one body; and what are ſuppoſed at its ſummit to be many new and ſtrange parts, are found to be no more than the natural extremities and terminations of the ſeven ſubſtances which form the entire body. Theſe external parts alſo are ſeven; 1. the Cup; 2. the outer Petals; 3. the inner Petals; 4. the Nectaria, either viſibly diſtinct, or connected in one thick ring; 5. the Filaments; 6. the receptacle of Seeds; and 7. the Seed-Veſſels, or Seeds. Of theſe parts of a Flower five only are accounted generally; for it has not been obſerved, that there is a diſtinction of outer and inner Petals univerſally in Flowers; nor has it been remarked, that where there are not viſible Nectaria, a thick and jointed cord always ſurrounds the baſe of the Receptacle. This will appear on more obſervation. The ſeven exterior parts never fail to be found the terminations only of the ſeven conſtituent ſubſtances of the Plant; when the maceration is well managed. The Cup terminates the outer Bark, the inner Rind ends in the outer Petals, the Blea forms the inner Petals, the Vaſcular Series ends in the Nectaria, and the Fleſh in the Filaments; the Conic Cluſters form the Receptacle, and the Pith furniſhes the Seeds and their Capſules. This is the general conſtruction of a Vegetable Body; it will be illuſtrated in the ſucceeding chapters, by particular inſtances, but here the entire view of the ſubject was neceſſary. We ſee by it, that theſe fourteen parts, ſeemingly ſo different, are reduced to ſeven: and we ſhall ſee theſe are univerſal in Plants; tho' their courſe be leſs plain in ſome, and their terminations leſs diſtinct in others. As to colour, we ſhall find that accidental, the ſame outer Rind is Brown in the Root, green on the Stalk, and Red in the Cup perhaps;



Black Helbore?



perhaps; while it is all found by this maceration to be one piece, one continued substance.

EVERY piece cut from a Plant transversely, therefore, contains all the parts of the Plant, ready to grow in length, into a Stalk upwards, and into a Root downwards; and to separate, at a due height from the Root, into the several parts of a Flower. This is plain and certain from the experiment; and this sets aside all the vague, and indeed absurd, opinions of Trees in their Seeds, and the innumerable Germs around their Trunks and Branches. Any transverse piece of a Plant, if it be preserved from rotting, is capable of growth; and every Seed contains what was originally in the globe of Farina, a detached piece of the Flesh, or essential part of the Plant; which is equally ready to grow as the other. The production of Plants from Cuttings, and from Seed, is therefore the same, only that the one is separated by violence, and the other by the course of growth.

THUS we see the arrangement of the common particles of matter into a Vegetable Body, altho' it be a work highly perfect, and worthy of his hand who formed it, yet is not so complex a thing as it appears: and that this arrangement being once made in one individual, the species is created for ever: for growth is the consequence of the arrangement, when it has heat and moisture; and there is no generation among Plants.

THIS is the general system of Vegetable Bodies; and we may from this proceed regularly to the detail of their parts.

C H A P. IV.

Of the PARTS of PLANTS.

A PERENNIAL of a firm texture, and not too complex composition, will be the fittest subject for separating the parts: I have therefore chose the BLACK HELLEBORE; a Plant which consists only of a Root, Radical Leaves, and a Flower Stem; and which is so hard in its substance as to blow in our coldest seasons.

THERE is another essential reason why I have chosen this Plant: to understand the parts properly, we must have them ENTIRE; and to begin from the true foundation, we are to trace them all from the extremities of the Fibres of the Root, to the part wherein they terminate.

IN most Plants these Fibres of the Root run to an extreme length; and terminate too small for sight, and too tender to be taken entire out of the earth. These, therefore, we could not examine: but in the HELLEBORE the Fibres of the Root are not more than five or six inches long; they may be taken out of the ground entire; and their extreme terminations are as thick as a large pin. Therefore they can be examined easily. See Plate I. where the Plant is represented in its natural size, and with all its parts.

C H A P. V.

The PREPARATION of a FRESH ROOT of HELLEBORE for this ENQUIRY.

ON the first day of January, 1759, I dug about a Plant of Black Hel-
lebores, at eight inches distance every way, clearing out the mould to
two spades deep; then getting the spade under the ball of earth left with
the Root, raised it entire. I laid this ball, with the Plant in it, under the
spout of a pump, and pumped on it gently, cleaning at the same time be-
tween the parts with a Camel's Hair Pencil, till all the earth was washed
away; and the uninjured Fibres were left clean and entire.

THIS is the Root which I have designed in the annexed Plate, with the
entire Plant growing from it.

C H A P. VI.

EXAMINATION of a FIBRE.

FROM this Root taking off a Fibre near its head, we see it is thick at
the top, gradually diminishing to the other end; and at different dis-
tances from the body of the Root it has three distinct appearances. If we
make an imaginary division of its length into three parts, as at Plate II.
Fig. 1.—1, 2, 3. we shall see it is of a pale brown, and smooth, the first
third of its length; the second part is of a duskier brown, and shaggy; and
the third portion is smooth, whitish, and nearly pellucid. It sends out no
sub-

subordinate Fibres; and the end is not diminished into an invifible point, but has a fair largeness for the view, and is terminated by a kind of button, 4. I have added it distinct, and a little magnified at *9.

THE portion (1) is of the nature of the body of the Root. Its surface is entire and smooth; it receives no juices from the earth, but conveys and improves those received below. The part 2, draws the principal nourishment; the shaggy surface is composed of Fibres of a peculiar kind. The part 3, is as yet only in the condition of one great Fibre. It will be proper to examine first the surface in these three parts, and afterwards the internal substance.

To this first purpose a thin piece of the surface should be taken off the whole length of the Root, with a very delicate Knife: and a piece of each part laid before the Microscope. The piece of part 1, marked Fig. 5, is a plain smooth piece of rind, with nothing rising from off its surface. Vessels appear within it, but of those we shall treat hereafter distinctly.

In the piece of part 2, figured here at 6, we see the shaggy surface is composed of little Fibres. These are short, pellucid, and very simple in their structure. We see in this piece the course of the Vessels, as in the former; and these Fibres take their origin always from these, and never from the interstitial substance.

To examine one of these small fibres exactly, it will be proper to cut off a very small segment of the piece 6, and laying it in water before the double Microscope, with a powerful magnifier, we see it as expressed at 8; differing in nothing from the part 3 of the large Fibre, except that it is more pellucid: it is a plain, simple, uninterrupted tube, terminated by a small button at the extremity, just as the longer Fibre. These twist themselves variously about, and the clubbed ends resembling the heads of Animals, they appear so many little serpents, or dracunculi, darting their small heads about with fury.

THE part remaining to be examined of the surface of the Root, is the third division or extremity. This being the same with the Fibres just named, only larger, will serve happily to disclose also their structure, Fig. 7. It appears simple; but when larger magnifiers are used, we find it, like the other parts, vascular: only all is more delicate. The great object of attention is the terminating Head or Button.

C H A P. VII.

Of the HEAD which terminates the FIBRE.

THE naked eye may see this head at the extremity of every Fibre plainly, in a Root thus cleaned: and it is impossible to look on it without surprise; it is so different from what the received opinions say concerning the extremities of Fibres. They are supposed small beyond all view, and open. On the contrary, we see them here enlarged and close. The greatest wonder is, that a thing so obvious, in a regular enquiry, should have escaped the observation of Naturalists so long. The depth of Winter is the time to make these observations; for the warmth and wet of Spring make great changes in the Fibres.

To the naked eye one of these heads appears obtusely conical, larger than the adjoining part of the Root, and altogether different in colour and substance; that is colourless and transparent, this part is opaque and yellow. No more appears till we cut it open.

A TRANSVERSE section of this part shews a very delicate construction, and very wonderful: but we shall be more familiar with the parts which compose it as we advance farther in the Anatomy of the Plant: for tho' they be thickened in a peculiar manner, they are the same seven parts which compose the rest of the Plant. See Fig. 10, 11.—counting from the centre, they are thus disposed.

THERE is a cavity in the middle of the head, and this is surrounded with a thin lining of white Pith, the same with the Pith of the Stalk or Fibre; round this is carried a thick coat of a greenish substance, which is the Flesh of the Plant, the fifth constituent substance of Plants, reckoning from the surface; and near the inner edge of this are placed six conic clusters of vessels, whose points pierce the Pith. These are the sixth constituent substance in all Plants. On the outside of the coat of Flesh runs a vascular series; it appears only in distinct Dots, but is composed of Vessels inclosed between two Membranes; this is the fourth substance in all Plants. Over this is a very thick coat of the Blea; which is whitish, and upon this are spread the two Rinds, the innermost of which thickens at the end of the head, into a kind of jelly. All these parts go compleatly round this head or extremity of the Fibre, returning upon themselves in so many arches; and there is no opening at the end of the Fibre;

Fibre; their course, as seen in a longitudinal section, is seen at Fig. 12. And if from these we direct the eye to the transverse and longitudinal section of a Fibre, Fig. 13, 14. we shall see the same parts most distinctly: for the seven substances are the same in the body of the Fibre, and in this singular head at its extremity; only that they are all larger, firmer, and more distinct in the body of the Fibre, and more tender, soft, and delicate in its head. Innumerable vessels are sent from the Flesh of the Plant thro' the Blea, as also from the Blea into the rinds in this part, for drawing nourishment, but none pierce the surface. The whole coat is spongy.

THAT Nourishment which this part of the Root receives from the earth, is not taken in at an open extremity, as was imagined; but enters the spongy cavities of this head; and being received into its substance, penetrates, in the same manner, the surfaces of those Fibres which run into this part from the other coats; and is thence distributed to the entire Plant, thro' their vessels.

THIS system is new; but the eyes are its evidences. The fourth Magnifier of the common Double Microscope shews it distinctly enough to ascertain the fact, that the end of a Fibre is a hollow head, where all the coats are continued round, and which has no opening: and the greater Magnifiers shew the communications of the Vessels as distinctly.

THE other opinion, that the extreme Fibres of Plants opened in a kind of Mouths at their ends, was, indeed, contradictory to reason; for the Juices must, in that case, have been received into the hollow where the Pith lies, whence there is no proper communication with the six other substances of the Plant. Perhaps the nourishment of Animals is received in the same manner, and the extremities of the Lacteals may be formed thus. One instance in animal nature there is which I have found plainly analogous: this is the Gordius, or Hair-worm. This creature has no mouth: its head is covered with just such a gelatinous substance as the end of the Fibres in this Plant; and all its nourishment pierces the pores in the same manner.

In Vegetable Nature every thing confirms this system; and therefore, altho' new, it will, I flatter myself, be favourably received. When Roots are shortened in transplanting, they first send out a gelatinous covering of this kind: and when Cuttings are planted, the first effort toward their growth, is a callous knob covering the wound. The Juices differ in these several instances, and therefore the substance of the head differs also in its firmness; but the proceeding is the same in all: Nature admits no

Juices to the Vessels of a Plant, but thro' the fine pores of such a head; and they are thence only given to the Vessels which run thro' the Body.

C H A P. IX.

The INTERNAL CONSTRUCTION of a FIBRE.

WE have seen the Surface and the Termination of a Fibre of the Hellebore Root; and the dissection of that last part of it naturally leads us to the Anatomy of the whole. For this purpose, we are to chuse an entire healthy and sound Fibre, taken fresh out of the ground at the season named before; and to examine it by transverse sections, and by splitting. The parts are most distinct in that portion which is next the body of the Root: therefore it will be best to cut it asunder at about half an inch from its insertion.

IN a thin slice cut transversely from this part of a Fibre, and laid before the Microscope, we see seven constituent parts very distinctly. Fig. 13. 1. An outer Rind; 2. an inner Rind; 3. a vast white Blea, composed of hexagonal Vessels; 4. a single series of greenish Vessels; 5. a greenish fleshy substance; 6. six conic clusters of Vessels; and 7. a snow white Pith, formed of Vessels extremely minute.

So much a transverse section shews. When we split the Fibre directly along the middle, we see the same parts distinctly in the same proportion; and on laying a thin piece of such a section before the Microscope, we discover the Vessels of which each part is formed. See FIG. 14.—1, 2, 3, 4, 5, 6, 7.

THESE seven parts continue their course to the extremity of the Fibre, and rounding that extremity in so many arches, return without interruption up again to the insertion of it at the body of the Root. The next observation leads us therefore to that insertion.

THIS is the plainest that can be conceived. There is no Joint, no Knot, not so much as a Gland, or Ganglion, at the part: but the two Rinds, and the Blea, and Vascular Series of the Fibre are continued plainly and simply into the Rinds and Blea, and the Vascular Series of the body of the Root. Fig. 15, 16. *c*. Thus far the Root and its Fibre are one continuous and regular body: but the Flesh, the conic Clusters, and the Pith, are distinct in each. 'Tis easy to see now in what manner a

Fibre is produced from the body of the Root: for tho' we have been obliged in the due course of enquiry to begin at the extremity of the Fibre, and follow it to the Root; that Fibre is, in the course of Nature, produced from the body of the Root, not the body of the Root from it. We are therefore now to change the course of examination, and consider the body of the Root: and are to trace this Fibre carefully from it.

C H A P. X.

The CONSTRUCTION of the BODY of the ROOT.

THE body of the Root in Hellebore is small; not tuberous, nor bulbous, nor of any determinate form; but a mere oblong, simple lump, irregular in shape, and composed of the same parts with the Fibres, which are thus disposed.

In the center is lodged a considerable quantity of Pith, inclosed in the Flesh and its Coats, and there kept distinct and separate from all other parts; having no connection with, nor continuation into any of them. This Pith follows the course of the Root in all its irregularities, at an equal depth within, and equal distance from its surface; nowhere coming within an eighth of an inch of the Rind, nor any nearer at the ends than elsewhere. Fig. 16. *a. b.* We see it is a mere exsudation of the fleshy substance of the Root, which surrounds it; produced from that, and producing nothing. This Pith is of a whitish colour, with a tinge of yellow. 16. 1.

JUST upon the verge of the Pith run the conic clusters of Vessels, scarce seen in a longitudinal section. 16. 2. The substance covering these is very firm, as broad as a small twine, and of a greenish yellow. Fig. 16. 3. This is the Flesh of the Root, and in the present instance it is very solid. It is easy to see by the connection of the Pith with this, that it is its proper lining; and is regularly produced from it.

THIS fleshy coat follows the course of the Pith, and in many places shoots processes of its own substance into it, and even thro' it, appearing like lines in a map, or letters of the alphabet. 15 c. These serve to support the two sides of the Flesh, at equal distance, where the Pith would not have strength enough to do it; and they divide it in a manner into so

many portions. This fleshy substance is every where at an equal distance from the surface, rounding the base in form of an arch or shell; and what may appear more strange, but is equally certain, pursuing its course in the same vaulted form at the top of the Root, 16, b. and under all the Fibres, 16, b. Tho' it sends out a part of its uter substance into them.

Thus terminates the Pith, the conic Clusters, and the Flesh, forming arches within the common coats, and returning upon themselves; but it is not so with the other parts. Next above the Flesh appears the Vascular Series, 16. 4. tho' very indistinctly in the longitudinal section: and over these lies a thick white Blea, 5. This is continued in an arch round the base of the Root, but it has no such termination at the head, 16, d, for there it runs up into the Stalk, making the same third part in its substance.

NEXT above this we find the inner Rind of the Root, 6. This is of an uncommon thickness, and is pellucid, and almost colourless, or of a very faint greenish white. This makes the gelatinous part of the heads of the Fibres, and is nearly of the same substance here.

OVER this is carried the outer Rind, 7. which is brown and thin. These are all the constituent parts of the body of the Root: of which the three innermost alone are peculiar in a manner to it. The rest are continuations of the same parts in the Fibres, and are continued also into the Stalks.

C H A P. XI.

Of the INSERTION of the FIBRES at the BODY of the ROOT.

THE body of the Root is the original part produced from the Seed of the Plant. It is, indeed, the Corculum or Heart of the Seed swelled and enlarged into that form; and the Fibres as well as Shoots for Leaves and Flowers are all produced from it. The Flesh in the Stalk of the original or parent Plant, furnished that Heart of the Seed; and this fleshy substance of the Root is the same thing swelled to a larger bulk. Its Pith has been thrown out from its own Vessels inward; and the several Coats externally have been produced in the same manner by its extravasated Juices hardened into a substance; and by continuations of those Vessels themselves in slender branches into it. Thus the fleshy substance in the body
of

of the Root, is the essential part of it: the rest having been produced from this: and so we shall find have all the other portions of the Plant. First we are to trace its Fibres.

WHEN we have laid open the body of the Root lengthwise, it will be easy to cut off a Fibre at a small distance from the surface, and splitting this along the middle, and carrying the knife in the same even line into and thro' the substance of the Root, we shall see plainly in what manner it is produced from it. Fig. 17. *a b c d e*.

THE Fibre, we have seen, is composed of all the same parts as the body of the Root. The two Rinds, and the Blea, and Vascular Series, are, indeed, continuations of those parts entire from the Root; the Flesh is a portion of the surface of the Flesh of the Root; but the conic Clusters and Pith are systems peculiar to each part. The origin of the Fibre is from the outer surface of the fleshy substance of the Root: 17, *a*. This part keeps its uninterrupted course along the body of the Root, even where the Fibre has its rise, 17, *b*, and forms a yellowish line between the base of the Fibre and the Pith, 17, *c*; but a part of its outer surface is raised horizontally in form of a small blister, whose crown is very thin, and whose body in a section represents two threads, 17, *d e*, a little distant one from the other. This Blister thrusts out all the coats of the Root in that part; and is the original of the Fibre. The Blea, where it is pushed by the tops of these two threads of the fleshy substance, goes with them outward with a small process; and so do the two Rinds. The fleshy threads are continued in length, and these three parts being also continued with them, a Fibre is formed, such as has been described; composed of a fleshy substance, a Blea, and two Barks, which are the same with those parts in the original Root, and, indeed, must be, because they are those parts themselves, only thrust outward. These accompany the course of the Shell or Threads of fleshy substance, till they have reached six or seven inches, which is the natural length of the Hellebore Fibre; and there the two threads which were at first one continuous substance, being only a kind of blister rising from the outside of the fleshy substance of the Root, form an arch or vault: this terminates that part of the Fibre. The three Coats, and the Vascular Series, are only the provisions of Nature for its security, and really nothing more than productions or continuations of the same parts from the body of the Root, for its service: these form the spongy substance of that singular head before described, and make a thick vault over it; and the others in the same manner surround it, not terminating, as has been supposed, at its extremity.

THUS we learn the true nature of a radical Fibre. It is not a new production from the Root; but is truly a part of the substance of the Root itself, first raised in a small blister on its fleshy part, and then carried outward into a considerable length. It is in form a lengthened cone; hollow, and crowned at the extremity with a protuberant head.

ITS conic clusters of Fibres, and the Pith, are all that remain to be considered; for tho' it receives nothing from the Pith or conic Clusters in the body of the Root, there are such cones of Vessels in the Fibre, and there runs along its center all the way, a certain quantity of absolute Pith.

WE have seen the first appearance of the Fibre was a blister on the fleshy substance in the body of the Root. The Pith of the Fibre is no other than a matter thrown off from the outer surface of the Flesh under the original blister, and is lengthened with the rest of the parts into the entire Fibre. The conic Clusters, which are original productions of the Flesh in all parts of the Plant, are in the same manner formed in this.

THE Pith is formed as that in the body of the Root; and the plain manner wherein we see this done in the present part, confirms the doctrine with regard to the origin of the other. In fine, a Fibre of a Root is no other than a long process of the body of the Root itself, increasing the surface to draw more nourishment. Fig. 18, is a longitudinal section of the same Root represented at 17, with the new Fibres more advanced in growth; at 16, c, is a Fibre yet longer: and at Fig. 23, is a split Fibre, with a piece of the Root magnified.

C H A P. XII.

Of the ASCENDANT SHOOTs.

THE body of the Root, in its course of growth, at the same time that it pushes out Fibres from the sides and lower part, sends also from the upper part, or crown, shoots which are to furnish Stalks and Leaves. The origin and structure of these are yet to be examined: and we shall then have cleared the Root, and may advance to the body of the Plant, its Leaves, and its Fruetification. This part of the Root, and the origination of Stalks and Leaves from it, may be considered in two views, as they appear two ways in Nature: 1. As the Germ, or Bud for a future Plant, is placed on the absolute crown or summit of the Root, 19, a; and

2, as a shoot or process of the Root, is formed for it, separating from the body of the Root at a greater depth, and bearing the Germ upon its head, 19, b c. The Stalks and Leaves of Black Hellebore are produced both these ways; and the latter, as most analogous to the formation of the Fibres, will demand the first consideration here.

THE origin of one of the ascendant flowering Shoots is this. The Root being filled with nourishment, and able to support more Leaves and Stalks than those which rise from its immediate Crown, a provision is made by Nature for more Heads, and more Crowns from below. The fleshy substance of the Root rises into a blister within its other coats, either near the top, 19, b, c, or at, perhaps, two thirds of its length or depth in the ground, d. This is exactly like those blisters which gave origin to the Fibres, only it is larger; and is directed upwards: it swells out in the same manner; and first forms a lump upon the surface of the Root. This grows from time to time larger and longer; and instead of making its way downward, as the Fibre did, keeps the direction upward. It reaches to the surface, or nearly so, and there it terminates. A Root of Hellebore with such a process, full grown, is represented entire at Fig. 20, and split at 21, where is also shewn a Fibre tending downwards.

THIS dissection shews the Shoot to be exactly like the Fibres in substance but not in termination. All the coats of the Root are continued up the whole length of this process; and a Pith soon arises from the fleshy substance at the base of the blister, 21, a. The fleshy substance forms an arch or vault just under the crown of this Shoot; returning into itself as in all other parts: but the coats do not return upon themselves in that manner. They terminate absolutely in the head of the Bud, and there form the first rudiments of Leaves and Flowers; every coat terminating in some one part. Thus we see the fleshy substance of the Root is one continuous body, surrounding it entirely; and is distinct in the body of the Root, tho' in part continued into the Shoots and Fibres.

THIS is the plain and simple formation of the ascendant Shoot or process of the Hellebore for flowering. The Head or Crown of that Shoot forming the rudiment of the future Plant, is constructed thus.

THE outer Bark of the body of the Root being continued to this process, ends in certain Scales at its top; see Fig. 22, which is somewhat enlarged, Letter a. These are the Scales a, in the principal Figure terminating 24, also the outer Rind there; the inner Rind terminates in certain other Scales, b, which are to be the outer Petals of the succeeding Flower. Close within these we see in the Crown the Vascular Series, 22 c, which

is very difficultly distinguishable in these longitudinal sections of the Root itself. Within this part, in the split Crown, appears a portion of the fleshy Substance, but not the whole, 22 d. The principal part of this substance makes the vault or arch by which it returns upon itself, and makes the entire communication round the Root; but a process of it rises in this Crown as a Blister; just as in the origin of the Shoot itself; and is continued into the Germ or Bud upon the summit. There it does not return into itself entirely, or form an arch of the whole; but a part is again sent off, and terminates like the outer substances, in many threads, which end in the future Filaments. Within this is a green line, which is a part of the conic Clusters, f; and finally a Pith is raised under this Blister as under the others, and this extending itself in length, terminates also in the rudiments of the Seed Vessels, 22, g. Thus is the Bud of Black Hellebore formed; and this as soon as formed, is defended by many Scales separated from the three outward coverings. This being understood, the formation of a Bud at the head, or proper crown of the Root, is known, for it is the same with that of the Crown in this.

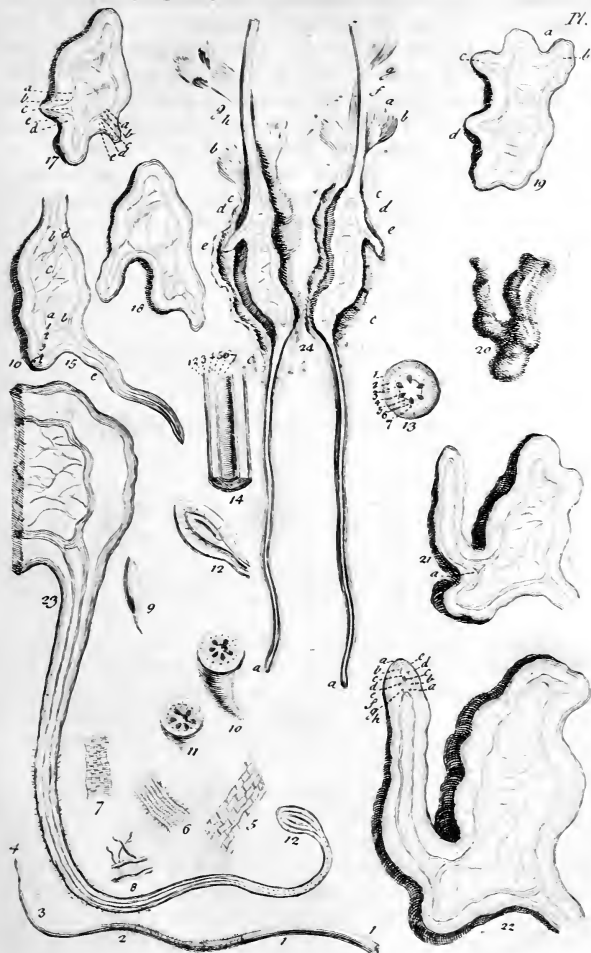
WE see of what parts the Root is composed; and we are now to examine the entire Plant.

C H A P. XIII.

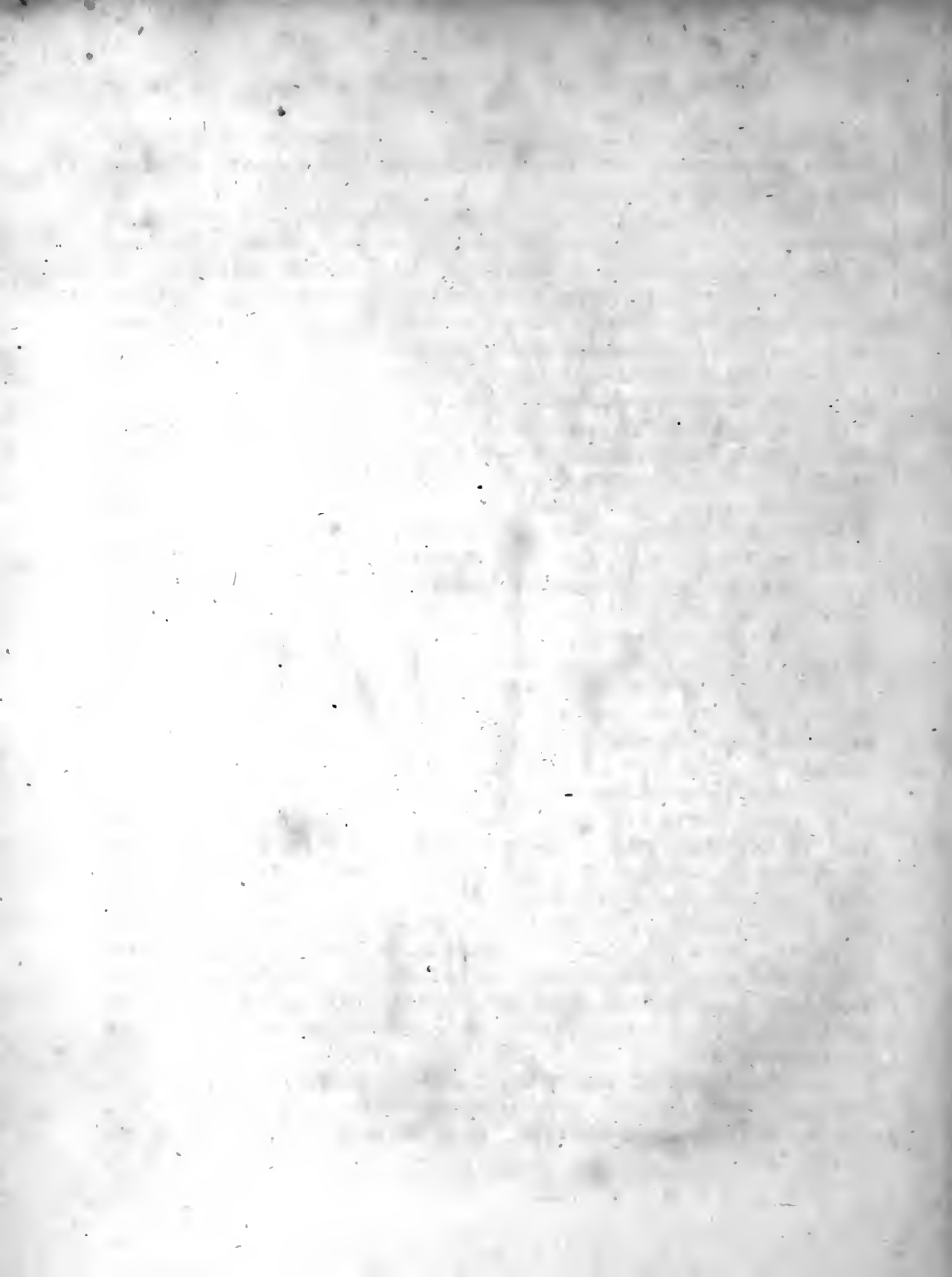
The CONSTRUCTION of the ENTIRE PLANT.

THE rational course will be, first to confirm, by more observations, what and how many are the constituent parts of a Stalk, as well as a Root, and Fibre, by transverse sections; then to separate these parts one from another by maceration; and thus enquire into their structure: and finally, by longitudinal sections of the fresh Plant, to see what are their connections, and how one is united to another.

THE first discovery we make by the transverse sections of the Stalk, the Fibre, and the body of the Root, is, that the constituent parts are the same in all of them in number and construction: differing only in proportion. And this is a discovery of no small moment. We find by this, that Vegetables have a composition peculiar to them as Vegetables; and universal among them: that it is as Plants they consist of a certain number of constituent parts; and that, as among the several portions of a Plant, Stalk, Root,



Construction of the Root.



Root, and the like, the only difference is, in the proportion of these constituent parts to one another, so it is also in regard to the greater difference of one species from the rest.

A CERTAIN number of constituent parts, therefore, are found in all Vegetables, and in all the perfect parts of every Vegetable. These the ancient philosophy held to be only three; the Bark, the Wood, and the Pith: later researches increased the number to five, accounting two Barks, the Blea, the Wood, and the Pith. To these, the observations it has been my fortune first to make upon this subject, have added two; increasing the number of constituent parts to seven: and if we add the membranes which inclose these several portions, the account will run much higher.

THE two parts I have found, and which had escaped the observation of others, are a Vascular Series between the Blea and the Flesh of Plants which last is the part analogous to the Wood in Trees; and an assortment of conic clusters of Vessels, taking their origin within the inner surface of the Flesh, and pointing inward into the Pith.

THEREFORE accounting the constituent parts of a Vegetable Body, they are, as we have before seen in the Hellebore Fibre, seven; and they are disposed in this order.

1. A THIN brown outer Bark.
2. An inner Rind, green, and much thicker.
3. A Blea, white in colour, and many times thicker than both.
4. A Vascular Series, or single course of Vessels, of a deep green, inclosed distinctly between two membranes.
5. The Flesh of the Plant, of a yellowish green.
6. The conic Clusters of Vessels, of a mixed green and white colour.
- And 7. the Pith perfectly white.

ALL these parts are seen distinctly in the sections of the Fibre, the body of the Root, and the Flower Stalk; sections of all which are given in Plate III. all these parts being portions of the entire Plant, proceeding from the Root to the Fructification. In the Stalks of the Leaves we see fewer; their simple office being only to imbibe moisture from the air, and to exhale the redundance of it at other times, for the nourishment of the Plant, and due motion of its Juices. These are therefore to be accounted only as a kind of appendages to Plants; nor are they of absolute necessity, for some kinds live without them: to the others all the seven constituent parts are necessary, because from them rise, in a plain and certain course, the Flower and Seeds.

THE Figures 25, 26, and 27, represent three transverse sections, or thin slices, of a Fibre, as they appear before the Double Microscope. 25 Is a section taken from the naked upper part of the Fibre near the body of the

Root. 26 Is a section cut out of the middle part of the Fibre, where it is hung about with Fibrills in form of Hairs. And 27 is cut from the plain and tender part toward the extremity. The seven constituent parts are equally present in all these portions of the Fibre, only they are less distinct where it is tenderest and most juicy toward the extremity, as at Fig. 27.

ADVANCING from the Fibre to a section of the body of the Root, we see all the same parts, and have them more distinct, as the subject is larger: and there we have the first instance of that difference they shew in the several portions of the Plant, beginning with a variation in number. In a transverse section of the body of the Root, cut extremely thin, and viewed before the Double Microscope, with its smaller powers, we see all the seven parts distinctly, as represented Fig. 28. Each has its regular place, and regular proportion to the others; but the conic Clusters are doubled in number. They were only six in the Fibre, but here they are twelve. In the Flower Stalk the parts are still the same, but they differ in proportion; the Blea is less in quantity, and the conic Clusters are there twenty-four. This is represented, moderately magnified, at Fig. 29, and largely and distinctly at Fig. 30. What remains is only to trace the parts in the Footstalks of the Leaves.

AT Fig. 31. is represented the body of the Footstalk in a transverse section magnified, which consists only of an inner Rind and Blea, with twelve of the conic Clusters; and at 32, is represented a like section of one of the divisions at the top, in which are only four of the twelve Clusters, a regular portion being sent into each of those parts.

WE are about to trace the course of these several constituent parts thro' the Plant, in the succeeding chapters; nor will this be difficult to an attentive eye, because they continue the same in all the portions of the Plant, whether they are continuations one of another, as the Rinds, &c. or generated in the part where they appear, as the Pith: but one thing is seen plainly in these sections, which demands enquiry here: this is the variation of the conic Clusters in number.

IT would be natural to suppose, that the six of the Fibre were continued into the body of the Root, and were there divided; and that the twelve of the Root became, in the same manner, the twenty-four of the Flowerstalk: but if this were the case, there must be many times twelve in the Root, for there are many Fibres; nor could the twelve we find there furnish the four and twenties of the several Flowerstalks; for they are very numerous from one Root. This is the Problem; and in a discovery to
new,

new, nothing must be regarded but plain observation. It will be necessary to the understanding Vegetation, to trace these conic Clusters very carefully, for their office is important, nor was it possible the Growth and Life of Plants could be understood while these remained unknown.

TRANSVERSE sections of the parts shew the place and disposition of these clusters, but 'tis in the split Roots we must trace their origin. To this purpose chuse a sound Root of Hellebore; split this perpendicularly down, and chusing a part for observation that has a Fibre growing from it, cut away the rest: then split this piece again, so that the knife may pass thro' the middle of the Fibre, and split that also down some part of its length, cutting off the one half by a perpendicular stroke. Such a piece of the Hellebore Root is represented Plate III. Fig. 33. and it is the only kind of section in which we can trace, in one view, the course of these clusters of Vessels in the Fibre, and in the body of the Root, so as to see what connection there is between these constituent parts, in distinct portions of the Plant. Such a section is represented Plate III. Fig. 33. The different faces in this figure all shew distinctly the several constituent parts of the Plant; and we see at Letter *a*, in what manner the same parts, namely the conic Clusters, and Vascular Series, are distinguished in a transverse section, which at *b* are scarce to be discovered in the longitudinal division, because they appear there only as a kind of Fibres running the same course with the rest of the parts.

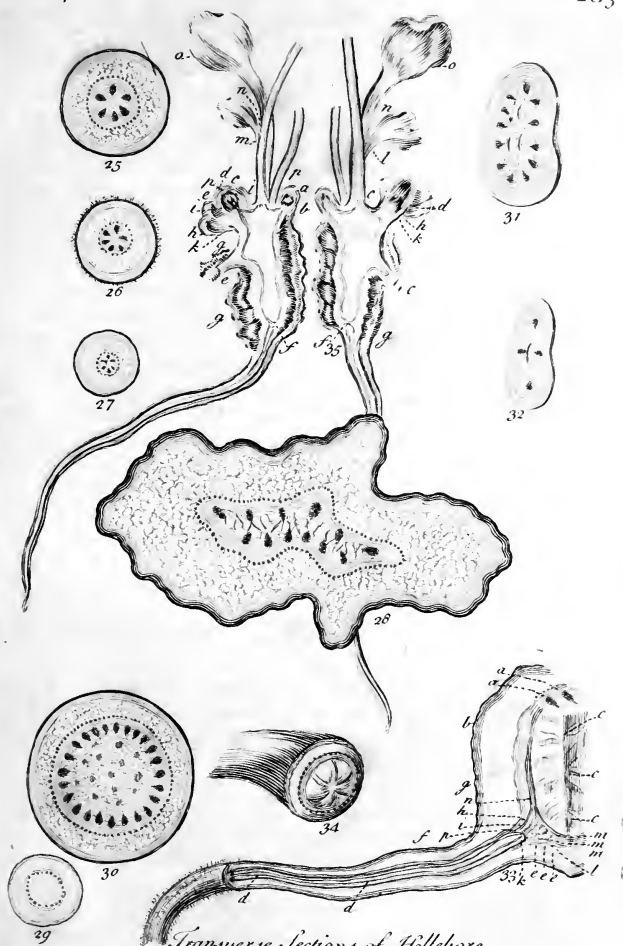
WE shall find, in tracing the course of the other parts in the pursuit of this subject, that the Flesh of the Plant does not run entire from the body of the Root into the Fibres; but the principal part of it pursuing a plain course round the Root, a portion only is sent off from its surface to form the Flesh of the Fibre. Therefore, in the body of the Root there is an hollow for holding the Pith, *c c c*; and in the body of the Fibre there is another, *d d d*. These two hollows we see do not open one into the other; for this section is made thro' the very center of the Fibre; and all that thickness of the Flesh of the Plant represented at *e e e*, has its place between them, nor is penetrated by any hollow whatsoever. Now the place of the conic Clusters of Vessels is always within the Flesh of the Plant, as appears in all the transverse sections of this Plate. Therefore the mass of impervious Flesh marked *e e e*, being between the clusters of the Fibres and those of the Root, they cannot be absolute continuations the one of the other, any more than the Pith of the Fibre and the Pith of the Root. Their situation is as distinct as their number.

WHAT is the absolute course of these Clusters in a Fibre at its extreme termination, we have seen; they are continued in arches round that extremity, returning upon themselves, as has been represented Plate II. Figures 10, 11, and 12. It remains to find in what manner they terminate at the top of the Fibre, where it is joined to the Root. To know this we must take off the Fibre *f*, from the body of the Root *g*, at the part *b*, not strait down transversely thro; but by an arched stroke, such as is marked by the dotted Line *i k*. It will be more proper to cut out an entire Fibre than one which is split, for this observation; but the divided piece of the Root 33, shews exactly where the knife is to pass. Many trials will fail; for it is essential to cut just under the arch made by the Flesh of the Fibre, without wounding the Vessels themselves; but with attention it may be executed; and if a Root be chosen for the purpose which has been a little while macerated in water, if some fragments of the Flesh remain on the top, a small pencil working in water, will get them off, and shew the course of the Vessels entire. We shall thus find that the conic Clusters of the Fibre not only do not run into the body of the Root, but that they never enter the Flesh at all; they return upon themselves in so many arches, just within the vault *e*, made by the Flesh of the Fibre, and constitute, as it were, another discontinued shell within that, surrounding every where the Pith. At Fig. 34. is represented the head of a Fibre, taken from a Root which had been some small time macerated in water, in which the six broad and arched lines are the conic Clusters preserved entire.

WE shall see in the succeeding chapters, that these Clusters of Vessels are, in the same manner, discontinuous between the Root and Stalks: but there is yet one observation which the present section of the Root offers, and which must properly find its place here.

ALTHO' the conic Clusters in the Fibre are not continuations of those in the body of the Root, there yet is a communication between them; and perhaps what thus is seen in the perfect Fibre, as a communication only, was originally the source of those Vessels.

On cutting off a very thin slice of the part of the Root, Fig. 33. *eee*, which is the mass of the Flesh of the Plant, between the Root and Fibre, and laying it in water before the Double Microscope, we perceive certain thick white lines, running a course contrary to that of the Vessels which compose the Flesh, and interwoven, as it were, among them; beside the multitude of these threads which must have been cut asunder in various angles, we seldom fail to see ten or twelve very conspicuous and entire, in



Transverse Sections of Nettlebore.



the thinnest pieces. They are represented in Fig. 33. at *m m m*. In any of these which are cut entire, we may trace the origin and insertion, as well as the whole course. In that part of the thin piece which has been a portion of the body of the Root, if we have been so happy as to cut thro' one of the Clusters, we distinguish a small line between the Flesh and Pith, of a mixed dark and pale colour. This is represented at Letter *n*, and its termination at *o*, shews that it is a longitudinal view of one of those Clusters; this section having been made so as to take the course of one of the twelve great Clusters just within the surface, the variety of colour is owing to the different coloured Vessels of which each of these Clusters is composed.

FROM one or other of the green Vessels of this Cluster arise all those white lines which pierce the substance of the interjacent Flesh, and make their way to the Clusters of the Fibre, where they form the vault or arch *p*, at the head. Being white, it would be natural to imagine they arose from the white Vessels of the Cluster; but palpable observation shews it is otherwise. I have sometimes thought I could distinguish a green thread in the middle of each. If it be so, they have only thick white coats, but carry the rich green Juice of the Cluster. The Flesh of the Plant gives passage to those Vessels, and as they proceed from the Clusters of the body toward those of the Fibre they unite two, or more, into one larger; and in this enlarged form they are plainly inserted into the Clusters of the Fibre. Probably this is the origination of the Clusters in the Fibre, and in these arches at the top of the Fibre the Clusters properly begin, being produced by the united branches of those small white Vessels from the Clusters of the body, and naturally enough extending themselves along each way, between the Flesh and Pith of the Fibre, till coming to the extremity they return in an arch, and reach the head again, where they began. This is the course of those Vessels in all the Fibres; and the Letters *e e*, *f f*, in Fig. 35 of this Plate, which represents the entire Plant dissected, divested of its outer Rind, and with the inner separated, and ready to be taken off, shew part of the very same construction with *b i l* in the Figure 33, only not enlarged enough to appear distinctly.

C H A P. XIV.

Of the COURSE and CONSTRUCTION of the OUTER BARK.

FROM this view of the place, and disposition of the several constituent parts of this Plant, we may proceed to trace their course and terminations; and afterwards their construction. The course and termination of the several parts can be truly known but one way, which is by separating each part from the rest, without tearing, or otherwise injuring it. This is a tedious and delicate operation; but it is not impracticable. The purpose is, to separate one by one the several coats and constituent substances of the Plant, beginning with the outermost, and working inward: this is not to be done in the entire Plant, nor while it is fresh and growing; he who should undertake such a task, would attempt what is impossible; but with the help of maceration, and a proper division, it may be effected. I shall direct others according to the method by which I have succeeded.

IN the month of January take up a Plant of Black Hellebore in Flower, getting it out of the ground entire. Wash away the mould from the Root, and laying the whole Plant lengthway upon a board, cut it across into ten parts. Each part will consist of many pieces of the Plant, but they will be all pieces of the same general portion of it. Thus the first parcel, counting from the bottom, will consist of a number of ends of Fibres; the second will consist of pieces of Fibres cut from a little higher; and so on. Let there be ready ten earthen pans, with about a pint of water in each; and mark them 1, 2, 3, and so on to the tenth. Into the Pan marked 1, put the first parcel, and the others, in a regular order, one parcel into each pan. Then tye a paper loosely over each, and set them by to macerate. Thus there will be a number of pieces of every part of the Plant for experiments; and by laying together one piece out of each pan, in the order wherein they are numbered, we may at any time make up the whole Plant. It was from pieces of this kind that I obtained all the preparations which confirm the following experiments. Different time will be required for the maceration of the several parts; therefore the experiments upon them should be often repeated: for what does not succeed in one state of maceration, will in another. The outer Bark is the

first part to be taken off, and we must begin with the body of the Root, because this coat is there most perfect, and was the original Bark of the Seedling Plant, the Fibres and Stalks, with their Bark, having been produced from it.

FASTEN a flat piece of cork with some cement, such as Cutlers use, to the bottom of a white stone plate; fill the plate with very clean soft water, and here begin the separation. Take one of the pieces out of the pan which contains some of the body of the Root. Wash the piece clean: split it down the middle, and lay one of these parts, with the split part upwards, upon the cork in the plate, and fix it with a couple of needles: I have fine needles fastened to long handles for this purpose. Then examine the edges with the help of a small magnifier, and there will be seen some places where the outer Bark is less firmly united to the inner than in others; these are a kind of openings made by the dissolution of the thickened Juices which had lain between the two Rinds; and having been seen with the glass, they will afterwards be more easily distinguished by the naked eye. Introduce the point of one of the hooked and edged needles into one of those openings, and then working gently between the two Rinds, the outer may be separated from the inner; and by pursuing this method with pieces from the other pans, we may thus obtain the outer Bark of the entire Plant separated from the other parts. We are not to expect that we can get this entire even from the most favourable pieces; but in how many fragments soever it is got off from the Plant, these being put together, shew us its whole course; and thus we know how much of the Plant it covers, and in what manner.

THE outer Bark of the Hellebore thus separated, and laid together in form, is represented in Plate II. Fig. 24. and thus we see its whole course on the Plant.

THE original outer Bark, is properly the covering of the Root, and nothing more. It extends from the extremities of the Fibres *a a*, to the surface of the ground *b*; but toward the top it suffers some change. From the extremities of the Fibres to the top of the Root, where the Stalks rise, it is of the same uniform texture and colour, thin and brown; but from the crown of the Root upwards, it becomes greenish, and is somewhat thicker, making a kind of shell for the outermost defence of the Bud *b c*. Great care must be taken in getting off the Bark from the Root just at the Crown, the part marked *c*; for it is very tender, and easily breaks there; but being taken off with care, we find the greenish part is absolutely continuous with the brown, and is its extreme termination.

THE

THE outer Bark of the Hellebore Root, therefore, covers it with all its Fibres, from the surface of the ground to their extremity, there rounding them without any breach or aperture, so that when separated from the rest, it may be compared to a glove, with numerous, long, and very slender fingers; but with no opening, except at the top.

THIS is the original outer Bark of the Hellebore, which is confined to the Root; but there is also a secondary one, which covers the Flowering Stalk. This Stalk first rises without any outer Bark, the inner Rind of the Root being its natural covering. This is represented in the Figure 24; the inner part of the Root being left within the separated outer Bark for that purpose, *eeee*. We see here the green inner Rind making regularly the outermost covering of the Stalk, the other terminating at *bb*, having covered that part of the Plant which was under ground: but the part *ff*, tho' it rose naked, does not continue so: a new outer Bark is formed for it from its own extravasated Juices, hardened by the air; and this covering the two Films *gg*, terminates there entirely. Thus there are properly two outer barks of the Hellebore, formed for the protection of the different parts of the Plant, and having their separate terminations; that of the original outer Bark being at the surface of the ground, that of the secondary one at the upper Film of the Flowering Stalk. These two Films originally fall over one another, and cover the Bud of the Flower; and thus the outer Bark, till the Flower opens, forms an entire covering for the Plant.

C H A P. XV.

The CONSTRUCTION of the OUTER BARK.

HAVING separated this outer covering of the Plant in a number of pieces, any one of these may be used for enquiring into the structure of the part; and there is little difference from whatever part it is taken, but it is most perfect on the body of the Root: this was the original part, the Fibres, and the Flowering Stalks having been produced from it: therefore in this it is best to seek its fabrick there: and by tracing it regularly in this, and comparing it occasionally with the outer Bark of other Plants, we shall not only discover the structure, but the uses of the part.

ONE

ONE of the small pieces of the outer Bark being laid in clean water, and rubbed over gently with a pencil, to wash off all accidental foulnesses, or remains of other parts, is in a condition for this examination. It is to be laid in a drop of water upon a plate of glass, and viewed with a very powerful magnifier. It thus appears a kind of net, with large irregular meshes; of a brownish colour; what resemble the cords of the net being browner than the rest. Whether we lay it with the outer or inner surface upwards, it has the same appearance. We perceive the meshes are not open; for in that case the interstitial part would be colourless; but on which ever side we view them, we discover that they are filled up by a membranous matter. A piece of the Bark thus appears as at Plate IV. Fig. 39. And examining the edges of the piece, we see very plainly this membranous matter, between the abrupt ends of the several Vessels *a a a*.

To examine the structure farther, let the piece be fastened upon a cork in water, and with a fine pencil work round all the edges, rubbing from without toward the center. By this means I have succeeded so far, as to separate the parts of which this Bark consists. Applying more power of magnifying, and laying a small piece of the Bark thus divided, with the outside upwards, we find that it is composed of two membranes, and a multitude of delicate Vessels laid between them. The outer membrane is yellowish, the inner whitish; and the Vessels are of a deep brown. As the two membranes naturally shrink when they are thus separated, the ends of the Vessels stand out in some places beyond them; and it is easy to perceive their mouths in those extremities. A piece of the Bark thus magnified is represented at Fig. 37. The Membranes are mere Films: the Vessels run upwards in a winding course, and are full of inosculations, joining with one another in innumerable places. They appear uniform and regular in their structure, except that they swell a little in some parts, and principally near the joints where they unite one with another. They are extremely slender; their colour is a yellowish brown, and they are palest where fullest of juice.

THE inner surface of this Bark remains to be examined; and for that purpose it will be proper to put on the very largest magnifiers. I am particular in the use of the Double Microscope, and combine upon these occasions two object glasses, by means of a larger tube which slides upon the tube of the Microscope: at the end of this I place a lens in one of those polished shells which are contrived for the Single Microscope for opaque objects. This is brought before the common object glass of the Microscope; and we have their combined powers. There is some difficulty in

fixing the place where the image from the first lens is best received by the second; but not so much as might be expected; when the two are properly placed, altho' they be separately but of moderate power, they exceed the first magnifier in the common way by many degrees, when thus united, and there is a larger area and good light; the shell of the lowest object glass very happily reflecting the light from that below.

A PIECE of the Bark laid with its inner surface upward, and managed as the other to separate the two membranes, makes before this great power of magnifying a very curious appearance. The membrane now thrown back is the white one; and we see it, both where it is loose, and where it yet adheres to the Vessels and to the other membrane, pierced with innumerable minute holes in different places, but principally near the Joints, and at those other parts where the Vessels swell. The piece of Bark thus magnified is shewn at Fig. 38; and the holes in the white membrane at Letter *a a a*.

If we now turn the piece of Bark, we shall find the yellow membrane which made its outer surface, is no where pierced in the least; so that these apertures are peculiar to the other. Examining the Vessels with this great power of magnifying, we perceive certain parts upon their surface which have a correspondence with these holes, and shew their use. At the joints of the vascular net, or those parts where the Vessels inosculate with one another, *b*, as also in the cross-arched bars which unite them, *c c c*; and in whatever part these Vessels swell, as at *d d d*, we perceive a roughness and irregularity of surface in them, not seen in other places. To distinguish what this is, we must use various degrees of light, and various positions of the object. There is scarce a more delicate thing among all the microscopic subjects. But with attention and unwearied trials, we shall at last see these parts of the Vessels in lights proper to shew to what their roughnesses are owing.

In all these places the coats of the Vessels are pierced with many minute holes, much smaller than those in the membrane with which they correspond; these holes in the Vessels are all round fringed with a number of minute yellowish hairs, which form a kind of pencil, whose point pierces the hole in the membrane opposite to it.

As there are no such holes in the yellow or outside membrane, so neither are there any visible apertures in the outer surface of the Vessels; only toward the extremities on the Plant they are entirely spongy. What may be the use of these singular apertures on the inner surface of this Bark, it is too early yet to seek; if the examinations of the other parts
shew

shew us their structure distinctly, perhaps it may be known when we view all together. Only this we may observe at present, that here is a provision of Nature for discharging some of the juice from the Vessels of the outer Bark, into the interstice between that and the inner, without the waste of any between the two membranes of the Bark itself. We see also the means by which these two coats of the Plant are fastened one to the other, and how maceration acts in procuring their separation.

THESE hairy fringes, which arise from the Vessels of the outer Bark, fasten themselves to the outer surface of the Rind under it; and as they are innumerable, and rise from so many and so near parts, they hold the two together through their whole surfaces: but as they are very tender, they are the first things that dissolve on lying long in water; and the band of union being destroyed, they separate.

THIS Construction of the Vessels of the outer Bark, explains also how it is that in the growing seasons we find a loose fluid between the outer and the inner Barks of certain Shrubs and Plants. In the Mezereon I have observed this particularly in early Spring; and it is evident in the Stalks of all the Bulbous Plants.

AT Fig. 39, I have endeavoured to shew the manner wherein the two Barks are united in the Body of the Root of Hellebore. The Figure represents a small piece vastly magnified, as it appeared under the polish'd shell and double object glass. *a* is the outer, *b* the inner Rind, separated by the needle, and curling backwards, as they do immediately on the separation. *c c* are the parts where the fringes of the mouths of the Vessels of the outer Bark fasten themselves to those of the inner.

AT Fig. 40, is represented a portion of the vascular part of the outer Bark, separated from its membranes: and as there is some small difference in the course of the Vessels in the outer Bark of *a*, the flowering Stalk, from that in the body of the Root, a small piece of the Bark taken from the lower part of a Flower Stem of the Hellebore, is represented at 41; and the Vessels enlarged, and taken out from the membranes, at 42. The course of the Vessels is straiter in the Stalk, from its length and slenderness, than in the body of the Root; and their cross-bars are less arched: indeed they are nearly horizontal; but the construction is the same in both. These have the same mouths, with the same fringes round them, and there are in the inner membrane the same perforations.

THIS is the construction of the outer Bark of Hellebore. Knowing this, it will be proper to examine whether the outer Barks of other Plants re-

seemle it. We seek, by these experiments, the laws of Vegetation, and the Philosophy of Plants; and they are not to be determined from what we see in a single species.

To render the observation easier, it will be proper to view the others with the same magnifying powers, and to take them as nearly as may be from the same parts of the Plants; therefore, as there is considerable difference in the shape of Roots, and as we see the course of the Vessels is somewhat altered by that shape, altho' their structure be the same, it will be best to fix upon the Bark of the Stalk in each kind, taking it off always near the bottom.

As Roots are thicker, the meshes of the reticular course of Vessels are wider, as in 36, 37, 38, and in consequence the cross-bars become arched by the force which separates the Vessels thus far asunder in the sides of the meshes; but in Stalks, as there is one general form from which they never vary much, that is, a slender cylinder, the course of the Vessels will not be subject to those innumerable variations which the different forms of Roots occasion.

IT was convenient first to trace the construction of this part, in pieces taken from the body of the Root, because it is there original, and the Vessels, and their mouths, are both much larger than in any part above ground: but there is equal reason for chusing the Bark of the Stalk for the object of comparison with that of other Plants, because being free from those accidental variations which the shape of the root gives, there will be no confusion in the enquiry; no accidental differences will be seen, and we shall therefore pursue more distinctly the real variations or similitude. The piece of the outer Bark of the Flowering Stalk of Hellebore, 41, shews that construction and disposition of the Vessels, with which we are to compare those of others. The Vessels in this run nearly strait, at tolerably regular distances; and the bars by which they inosculate one with another, are placed at a considerable distance, and disposed nearly at right angles with the others. The fringed mouths in these are very minute, and are placed principally at the joints, and in the cross-bars.

In the outer Bark of the ANEMONE the Vessels are much thicker, and the cross-bars very slender; in these the mouths are placed at small distances all along the inner surface of the longitudinal Vessels, and the cross-bars serve merely for communication between one of the ascending Vessels and another; they are so slender that they appear as mere Fibres; and their cavities are inconceivably small.

THE

THE Pulsatilla, which comes next in this gradation, shews that these bars are not of absolute necessity to the use of this part; for in its outer Bark there are none. The Vessels are large; they are placed much nearer to one another than in the Hellebore; and they have no communication one with the other. I have traced a single Vessel from the bottom to the top of the Stalk, and found it no way, nor no where, joined to the rest. These Vessels have their opening inward, as in other outer Barks; but it is in a manner very different from the former. The juices they convey are thicker and more coloured than in the generality of other Plants; and there are at various distances in all the Vessels a kind of Glands, at which they stop: these are darker than the rest of the Vessel, and somewhat swelled; and lengthwise of each swelled part, there is opened a small slit, which has no fringe or hairyness about it. This slit pierces the inner membrane, and can discharge its liquor into the space between this Rind and that next under it.

THE Stalk of the Pulsatilla is extremely hairy; these hairs are white tubes, rising immediately from the surface of the Vessels, and opening with a plain mouth into them.

In the Polyanthous Primrose, the Vessels are disposed exactly as in the Hellebore Barks, only the bars are smaller, and the openings are by round fringed mouths along the surface of the ascending Vessels. The Bark of this Primrose comes off very freely, but it is difficult to get the outer one pure. The colour of the Stalk is owing to the inner Rind; for the outer Bark is perfectly colourless: this will shew whether the two come off together, for we never see the outer Bark alone, unless it be very thin and perfectly colourless.

THE outer Bark of the Narcissus affords a much more pleasing appearance: it is thin, perfectly colourless, and very distinct in the construction. The Vessels in this are very small, and the fluid they contain is entirely watery; they are made into a kind of links, joining by the ends, and being thus united in pairs, there are also cross-bars, as in the other Barks, but not between the two Vessels of the same pair; these are joined only by the ends of the links: the cross-bars go from the outsides of each of these Vessels, to the outsides of the Vessels of the next link.

WE trace the course and form of the Vessels in this Bark very happily; for there are no apertures either in their surfaces or in the cross-bars; no fringe of hairs to disturb the view, nor coloured juices, irregularly lodged, to intercept it. The whole construction is plain; and that communication Nature always makes between the Vessels of the outer Bark and the interior

terstice between that and the inner, is thus preserved. At the joining of the links there are a kind of knots: not at every joint, but at every third, fourth, or fifth, so that in the whole they are very numerous. These knots have their origin from an opening which is between the two ends of the two links; for they are fastened to one another at the two edges only, and not throughout the whole part where they touch. From this opening in the center of the joint rises a small Cone; at the top of which is a long and very narrow slit; which is capable of being distended or contracted, according to the state of the Plant. The inner Membrane is cut in the same form at every one of these slits; and the glandular swelling round the aperture, alone preserves all the juices from being discharged this way: this serves the same purpose with the hairs in the other Plants; and in the same manner unites the outer to the inner Rind.

IN the Hyacinth, the outer Bark is equally distinct and colourless. The Vessels are slender, they are placed more distant than in the Narcissus, and are joined to one another by cross-bars, as in the Hellebore. The mouths by which they open into the interstice of the two Barks, are glandular, and conic, as in the Narcissus; but they are larger and fewer; and they do not rise at the joints, but are the absolute terminations of certain branches of the Vessels. So that in this Plant, while the greater part of the Vessels pursue their uninterrupted course upwards, others terminate at different heights, and in considerable numbers, in absolute glandular heads, discharging their contents between the two barks, and fixing one to the other. Round each of these glands, as also round the others in the Narcissus, and in all the Plants of this kind, there is continually seen a kind of bladder of a peculiar Juice. This is the liquor discharged from the Gland, which makes its way slowly at the minute openings of the inner Membrane; and it is evident, that the Juices thus discharged, have suffered an alteration in the Glands, for they are thicker and more coloured than those in the Vessels. Often these Glands appear to rise from the Membranes themselves; but there is always a communication with the Vessels.

IN the outer Bark of the Stockjulyflower, the Vessels are large and branched; they run a less regular course than in any of the preceding; but they are joined by cross Vessels in the manner of bars, one to another, as all the rest. At many of these joints, but not at all of them, there are round simple swellings; perforated by very minute and naked holes, which open into the interstice between the two Rinds.

IN the outer Bark of the Pervinca the construction is very like that of the Bark from the body of the Hellebore Root: the substance resembles a

net from the distance of the ascending Vessels, and the frequency of the cross-bars: but these are notwithstanding strait, and not arched as in the Hellebore. The fringed openings are disposed and constructed just as in the Hellebore.

IN the Bark of the Black Currant they are in the same manner formed into a net of broad short meshes, but with somewhat arched divisions: and the whole surface of the Vessels on the inner side is pierced with small holes, with a few fringed hairs about them.

THE uniformity of Nature in the essential part of the construction of these various Barks may shew there is one general form, and one certain office, in this part of Vegetables, which is alike performed by all, and for which it is in all Plants destined and ordained. From the extreme Fibres of the Root the Vessels of this Bark carry up Juices, in a short course, to that part in which they terminate, which is usually the Cup of the Flower; in their way discharge part of their contents into the interstice between the outer and inner Rind; which matter so discharged, has not the colour or consistence of that carried along in the Vessels; and therefore we may reasonably suppose it is not discharged simply from their cavity, but passes thro' minute Glands seated at the orifices. Doubtless this once concocted aliment is received into the interior part of the Plant; not discharged to waste. That these Vessels receive more than they are destined to carry to the extremity of the Plant, is evident; for in those species whose apertures are small inward, hairs, as they are called, rise outward on the Stalk, which are only simple tubes, discharging, during the heat of the day, a part of their Juice. So far as I have yet observed, where hairs are wanting, there are parts of the Vessels which rise spongy to the exterior surface, and stretch the Membrane till it cracks over them: these answer the same purpose as the hairs on others, in throwing off a part of the Juice; and they can also imbibe. I have tied up the bottom of a Narcissus Stalk to the neck of the Flower, and setting only the entire arch in water, the Plant has been tolerably well supported: unopened Flowers have blown from this nourishment, and the general tuft of Bloom has lasted nearly as long as in those which had the cut end of the Stalk plunged in the water.

C H A P. XVI.

Of the INNER RIND.

THE inner Rind is, in the generality of Plants, much thicker than the outer; and of a looser texture: in the Hellebore Root it differs in colour considerably, as well as in proportion, being green, whereas the outer Rind is brown. Often the Stalks of Plants are coloured, and the red, in this case, appears superficial; it is really in the inner Rind. The Polyanthus is a very familiar instance, in which, tho' the Stalk be highly coloured, its outer Rind is perfectly colourless. When we seek the origin of this inner Rind, we must trace it in the body of the Root; that having been the rudiment in the Seed, and its first production in the ground: from thence it is continued downward, over all the Fibres, and upward into the Flowering Stalks, and Footstalks of the Leaves. In these last it is the exterior coat, for Nature has allotted them no outer Rind: in all the others it is covered by the outer Bark just described, so far as that part reaches on the Plant; but this is extended every where somewhat beyond it: therefore the Footstalks of the Leaves are not the only part where we may expect to see it naked.

In the Hellebore, when it has covered the body of the Root and Fibres, it ascends with the outer Bark to the surface, having a very essential service in the Crown of the Root. Its course is represented in Plate III. Fig. 35. where a single Plant of the Hellebore is figured split open, and divested of the outer Bark; the inner Rind being also separated on each side from the substance next within it. This is its extent, and this its course: when it has nearly reached the surface of the ground, it loses the strong green colour it had in the body of the Root *gg*, and becomes whitish, *bb*; terminating, while the Bud is yet fixed upon the Crown, in a vault or shell, *ab*, covering such another shell formed of the Blea, *dd*; within which rests the Rudiment of the Flower, with its short Stalk, *ii*, ready to be enlarged by heat and moisture.

WHEN it begins to grow, the Bud forces itself upward with the Blea and bursts the shell formed by this inner Rind: the Bud then appears with a round head above it, as at *d*; and the termination of the inner Rind seems to be in a circle round it, as at *cc*. But this is an accidental and a forced termination; and the real course of the inner Rind is independant
of

of it. The broken Shell fades down to the part *k*, where it began to rise loose from the Blea; and the inner Rind pushing upward from that part, not only gets a new outer Bark for itself, but follows the course of the Blea upward in the ascending Stalk.

WE have seen that there was originally also a shell of the outer Rind over the Bud at the Crown of the Root: this and the shell of the inner Rind being both broken, there remains only the third shell or Blea over the young Flower, which is formed of the Flesh of the Root. As it rises higher this third shell ascends with it: where it ceases we shall presently see; but now, ascending entire, the power of growth being strong in the inner Rind of the Root, this coats it over; and having, from its extravasated Juices renewed its own coat, or formed what has been called the secondary outer Bark of the Hellebore, the Bud rises so far perfect.

AT some height above the ground the vigorous Flower breaks thro' the Shell *d* also, which being thus split, spreads off sideways, and constitutes the internal substance of those two Films, *l m*, which in this young state cover the Flower. The outer and the inner Rind having risen with the Blea, spread themselves also over these Films, and cover them entirely. In the uppermost of these, *m*, the new outer Bark entirely terminates; but the inner Rind, *n n*, still pursues its course up the Stalk, even to its summit, where spreading into Breadth it forms the two under or outer Petals of the Flower, *o o*, and there terminates entirely.

THIS course of the two Rinds is peculiar to the Hellebore, and some few other Plants of the like kind: for in the generality of Herbs the outer and the inner Barks rise together with the Blea, in a plain continued and uninterrupted course, from the Root into the Stalk. As the young Bud of this Plant must pierce the earth in the severest Frosts, Nature has by this peculiarity of structure in the Crown covering it, provided for its defence.

C H A P. XVII.

Of the CONSTRUCTION of the INNER RIND.

THE outer Bark having been removed from several pieces of the Hellebore, all these are now ready for the taking off the inner, which we are about to examine; and if they have been left in the water till now, they will be in a condition to part with it the more easily. It is nearly in-

different from what part of the Plant we take a piece of this Rind for examination, for there is not variation in the disposition of the Vessels in the body of the Root and other parts, which we see in the outer Bark : it will be best therefore to take the piece for examination from the Flowering Stalk just above the ground, that being the part easiest compared with others.

A SMALL piece of the inner Bark of the Heliebore thus separated, and cleared perfectly in water with a camel's hair pencil, appears composed of many couches, beds, or flakes of an uniform matter, laid evenly upon one another. This is the first and most obvious distinction between the inner Rind and the outer Bark ; the last being one simple flake, composed only of two Membranes with a reticulation of Vessels between them. These numerous couches give the thickness of the inner Rind ; for each couch or bed is not thicker in this than in the outer Rind.

THE first care must be to separate one single couch of these from the rest : they are all alike in structure, but when they lie one over another, the object is confused. A small piece of a single couch of this Rind appears before the Double Microscope perfectly transparent, and almost colourless. The Vessels stand at considerable distances, ascending in waved lines, and inosculating often one with another. There are a great number of Bars joining these Vessels one to another ; and these are not arched or transverse, as in the outer Bark, but always oblique : such a piece, as it appears to the Double Microscope with a very considerable power, is represented Plate IV. Fig. 43.

By working upon a small piece in water with fine camel's hair pencils, we can separate the Membranes from the Vessels in this as in the other Bark ; and a larger power of magnifying being applied, a piece thus prepared, shews that each couch or plate of this Rind consists of two Membranes, with a series of Vessels between them ; as the compleat outer Bar : but these large powers of magnifying shew us also something more, for between those Vessels there is a spongy substance, filling up every where the spaces ; tho' unless by a very careful eye, scarce to be distinguished from the Membranes themselves. A piece thus magnified, is figured at 44 : and the three distinct parts of which it is compos'd, at the three following numbers ; 45 represents a piece of one of the Vessels separated, and yet more powerfully magnified ; 46, the Membrane ; and 47, a fragment of the spongy substance.

WITH this great power of magnifying we see the construction of the Vessels very plainly. Each is a simple hollow tube, fludded on all sides,

as it were, at small distances, with a kind of oval Glands, 45, b. In these there is no simple aperture, as there is in the swellings of the Vessels of the outer Bark; but they seemed pierced all over with very minute holes, from which there issues a whitish fluid, thicker than the Juice of the outer Bark.

BESIDE these prominent parts, whose purpose plainly is to discharge an abundant moisture, there are others of the same form, and equally numerous, which are of a dusky colour, and are a little hollowed inward. The office of these seems to be to receive.

THERE are distinctly shewn in the large Vessels, at the Figures 48 and 49; the first of which represents a piece of a single Couch of this Rind, with its two Membranes separated, as it appears before a very great power to the Double Microscope; and the latter, the Vessels of the same part taken out from between those Membranes.

AFTER this examination of a single Couch of the inner Rind, it will be proper to examine the several together which make up its whole thickness. We find by this view, that the Vessels in all these Couches are united to one another, by those short obliquely disposed Vessels, which we call the Bars of Union; but that there are none such between the Vessels of this Rind and of the two distinct substances placed next to it. The communication between the outer Rind and this, is only by the mouths of the Vessels of the outer Bark, which open into the interstice between the two, and those of the inner Rind, just described as depressed, not rising above the surface. This is the more certain, because there are only the depressed mouths on the outside of those Vessels of the inner Rind, which form the outer Couch, and come next to the outer Bark. This is expressed in the Figure 48, which is the outer surface of a piece of the outermost Couch of this inner Rind; and in 49, which exhibits the same surface of two of the Vessels taken from between those Membranes. It appears by these examinations, that the cross-bars which join the ascending Vessels one to another, are also tubular, for they have the same mouths upon them.

BY these gradual advances we make some progress toward a knowledge of the Vegetable Structure: we see the communication between the several Couches, which together compose one substance, is of one kind, and that between one substance of the Plant and another, is of a distinct sort. Thus the Vessels of the several Couches which form the inner Rind, are united simply by tubular bars, in the same manner with the separate Vessels of the same Couch; the original Juice received into the part passing with

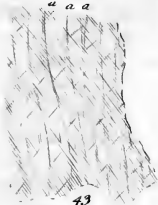
equal freedom from one Vessel to another throughout the whole substance : but between the outer and the inner Bark, the communication is altogether different : part of the Juices from the Vessels of the outer Bark appear, indeed, to be received into the Vessels of the inner Rind ; but it is after extravasation ; and after an alteration plainly made in the Glands, which discharge them ; probably also, after another made in the glandular mouths, by which they are received.

ANOTHER part of Nature's operation in perfecting the Sap, appears also very evidently and very singularly in the construction of this inner Rind. Beside the Membranes which inclose these Vessels, there is a spongy substance between them : the same Vessels also have Glands for discharging, and mouths probably glandular also, for receiving fluids ; and this in parts where no Juice can be received by the one, but what has been first discharged by the other. This is evidently the case of the middle Couches of this Rind. It seems, therefore, that part of the Juices of these Vessels is discharged thro' the prominent Glands, into the interstice between the two Membranes, and there received by the spongy substance before described, in which it suffers some change, and is then received by the hollowed or depressed mouths of the same Vessels into them again. However this be, the construction of the parts is evident, and we see what is the connection of the outer and inner Rinds of Plants.

PURSuing this subject as the former, thro' other instances, we find that in the *Polyanthus* the inner Rind is constructed exactly as in *Hellebore*, only the Vessels are more distant, and in some places divide into two, in their ascent. In the inner Rind of the *Anemone*, the Vessels are placed yet more distant, and run quite strait. In both these the two kinds of glandular mouths, the prominent and the depressed, are placed as in the *Hellebore* ; only in the *Polyanthus* they are very minute, and thick set ; but in the *Anemone*, on the contrary, they are much larger, and more distant. In the *Hyacinth* the oblique bars are larger and more numerous, but otherwise the construction is entirely the same ; the Juices of this Plant being thick, it is difficult to get the parts perfectly clear of one another ; but the Glands are seen to more advantage.

IN the *Narcissus* the Cross-bars run less obliquely ; the ascending Vessels swell between joint and joint, and the Glands of both kinds are numerous, but minute, and are situated only on the swelled part. We see by these examples, that altho' the disposition of the Vessels of this Rind varies a little, their construction is the same ; and we thus know what is the structure of this second of the constituent parts of every Plant. All

Inner Rind.



43



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46



45



47



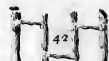
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49



41



42



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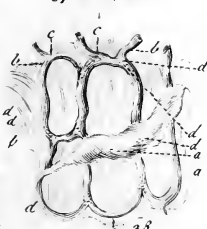
Outer Bark.



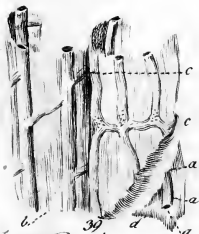
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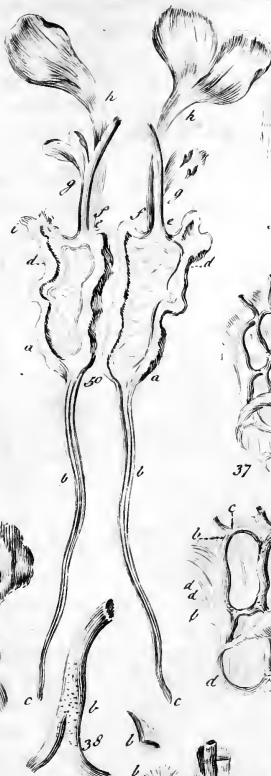
37



38



39



Anatomy of the Outer Bark & Inner Rind.



that we can wish more, is to see the structure of the inner surface of the innermost coat of this Rind in Plants, because that comes next the Blea; and Reason says it should have the same connection with it that there is between the outer and the inner Rind.

THIS Coat may be obtained separate; but it requires great care, and a nice hand to get it. We find it composed, as the others, of a series of Vessels between two Membranes; but the Vessels are larger than in the rest; and the spongy matter here is very little. On the outer surface of these Vessels there are only receiving, that is only the depressed mouths; and on the surface next the Blea, there are only the prominent oval Glands, which seem made for the discharge of the abundant fluid. It seems, therefore, that while the waste part of the Juices of this inner Rind gently ascend to the top of the Plant, there is a part of them elaborated by various changes, and at last delivered to the Vessels of the innermost Couch, which give it to the Blea.

C H A P. XVIII.

Of the C O U R S E of the B L E A.

THE Blea of Plants, which is the third substance in our transverse sections, is seen great in quantity, and seems composed of very large Vessels: this appearance however is deceiving. What seem Vessels, are but the interstices between Vessels; the vascular part being very minute in this, and all the vegetable frame.

IF we trace the Blea, as we have done the outer Coats, we shall see it covering the entire Plant, immediately under the inner Rind: and its origin being placed in the body of the Root, we find it descending the length of the Fibres, and rounding all their ends, ascending to the body of the Root again, and thence running up the Flowering Stalk, and Leaf Stalks, losing itself in the Leaf Stalks, at that part where the extreme Fibres of the Leaves themselves end; and terminating absolutely in the Flowering Stalks in the three inner Petals of the Flower. This course of the Blea is represented in Plate IV. Fig. 50. in a Plant of Hellebore made up of several pieces, divested of the two Rinds, and with the Blea, which is there its outer covering, laid back from the parts within.

FROM

FROM the body of the Root, *a c*, which was its original part in the Seed, and in the Seedling Plant, its course downwards into the Fibres, *b b*, is plain, and it rounds them at *c c*: ascending thence to the Crown of the Root, at *d d*, it enters the Leaf Stalks, *e e*, by a plain and simple continuation in growth upwards; but its ascent up the Stalk for flowering, is a matter of more delicacy: we see it in this full-grown state of the Plant, ascending simply up the Stalk, in a continued course from the Root, at *f f*, just as in the Leaf Stalks: at *g g* it forms a fleshy lining of the two Films, which is here represented as it appears when stripped of the inner Bark; and finally at *b b* it comes to an absolute termination in the Petals.

AT *i*, the Flower, with its rudiment of a Stalk, is represented in the Bud; but to see this more distinctly we must refer to the preceding Plate III. where, at the Letters *i i*, *c c*, *d d*, the construction of the Bud, and course of this part are represented more at large; because with all their parts. The Bud *p*, lodged within the shell *b*, is encompassed there by the Rinds and Blea. The Rinds fall off as the Bud rises, as at *c c*; and finally the inner Shell *d*, now exposed to the air, bursts also from the rising of the Bud, in the same manner. It might then seem that the Bud, *p*, should rise naked thro' it: but Nature has contrived otherwise. The whole inner Rind rises in the Shell, *c c*, but the inner Shell, *d*, is not formed of the whole Blea, but is a duplicature only, rising from the part *g*; where the base of the Bud is formed upon the Flesh of the Root. Therefore the rudiment of the Stalk, which lies here, is covered with its proper Blea; from the surface of which only rises that portion of it which forms the Shell: and for this Reason, when the Shell bursts as the Stalk rises, its divided parts, *c c*, rising with the Stalk as far as *l m*, there form the inner body of the two Films; but the Stalk rises cloathed with its Blea, from *g* to them, and above them, till it terminates at the three inner Petals. These Petals, which being carefully folded over one another, form the head of the Bud, *p*, have therefore the extremity of the Blea upon them, when they pierce the Shell, *d*, formed of a duplicature of it, and afterwards forming the bodies of the Films.

C H A P. XIX.

Of the CONSTRUCTION of the BLEA.

HITHERTO we have seen the Coats, or constituent substances of a Plant, simply surrounding, or plainly and uninterruptedly covering one the other ; but in the Blea it is much otherwise. This makes a coat much thicker than the rest ; but the next substance under this runs into it in various processes. I cannot wonder this has not been observed, for few have had the attention to consider Plants in the various effects of maceration ; and it is only in certain states, tending toward decay, that this wonderful construction can be seen. This being first understood, we shall be in a condition to examine the construction of the Blea ; by being aware of a different part thus mixed among it. As it is the Flesh of the Plant which thus runs in among the Blea, the different colour of its Juices will distinguish it to the cautioned eye. The Juices of the Blea in Hellebore are mucilaginous and whitish ; those of the Flesh are green and coarse. They are to be seen in the Vessels making the corners of the hexagon Cells ; which Cells are also larger.

Thus prepared, we are to examine the Blea ; and as it is a part of considerable thickness, it will be best first to consider it in the transverse sections, as in that enlarged part of the Root, Plate III. Fig. 28 ; and of the Flowering Stalk, Fig. 30 of the same Plate. We find in the thickness of the Blea in these various parts, from six or eight, to fourteen or more beds of hexagonal Cells ; and it will be proper first to enquire what these are. They are Membranes, whitish, and very thin ; but at the angles they have a thicker aspect, and on examining more strictly, we find this thickness arises from a Vessel in each of those Places. These Vessels are considerably larger than in either of the Rinds ; and we plainly enough discern their cavities, when it is a new-cut piece that we examine. These Vessels form the solid part of the Blea, and they are connected and kept in their places by Membranes. They rise in distinct arrangements, six in each ; and these make the six angles of the several hexagonal Cells. Therefore the Blea is not composed of various Couches of Vessels between two Membranes, as the inner Rind ; but is one compleat and single substance, uniform in its structure ; and the whole of it is contained between two Membranes, which are thin and pellucid. The Juice, which is abundant in these Vessels,

continually

continually discharges its watery part into the Cells between them; and perhaps there are other sources of a simple fluid which fill them. Certainly the great quantity of water imbibed and perspired by Plants, is principally lodged in these Cells of the Blea.

HAVING thus far examined the general structure of the Blea, we are to proceed in our search, by taking off a thin piece from its outermost part lengthwise. Such thin pieces are easily obtained from the thickness of the inner Rind, because it is composed of separate Plates or Couches; but in this we must obtain by art what offers itself so easily there. To this end, having separated the two Rinds clean from a piece of the Flowering Stalk of Heilebore, we are to raise a thin piece of the Blea with the point of the Lancet-scissars; and taking hold of it with fine Pliers, to tear it off, lengthwise, and upward, from the rest. The thinnest part of this is to be worked well on its inner surface in water, with a camel's hair pencil; and with due care we may wash away all but one series of Vessels and their Membranes. The inner surface will be irregular, but the thickness will be no more than that of one Couch of the Rind.

WE thus see the Course of the Vessels, rising in a curved manner, and connected together by very frequent arched ones, placed, as the cross-bars, in the two Rinds; but with this great difference, that here what appear as arched parts in this view, when we see the whole more enlarged, are found to be really portions of the Vessels themselves, not separate Vessels arising from them, as in the Rinds.

A PIECE of the outer surface of the Blea, with the exterior side uppermost, appears to the Microscope with a considerable power of magnifying, as at Fig. 51, Plate V. What strikes the eye first in this view is, that there appear a kind of interstices at the places where the Vessels pass over one another: but this is the natural result of their form. These Vessels do not run up straight, as those of the Rind, but bend backward and forward, repeating from space to space, the form of the letter S. Any two of them which run in this form, in an opposite direction, will cross one another at the two places where the bend is made, and consequently there will be formed between them two elliptical figures, or one such figure by each half of the double S. This cannot be seen distinctly in a piece of the substance managed as at Fig. 51, because the Vessels will have been forced a little from their original course, by the violence used in preparing the piece; but even in that fragment which is engraved exactly from Nature, something of this general course may be seen, and the whole will be understood distinctly

tinctly by the parts of two Vessels taken out from the Blea, and laid in their natural form, as at Fig. 55.

THE ends of these two Vessels, *a, b, c, d*, proceed in their natural course to form two other such elliptical spaces, as *d*, and being on each side touched by others of the same kind, and running in the same manner at *e e*, there must necessarily be little spaces at the angles *f, g, h, i*, the same with those at *a a a a*, in Figures 51, 52, 53, 54.

THESE Vessels of the Blea, where they pass one another, as at *k k*, Fig. 55, do not simply go over each other, but absolutely inosculate, or open into one another; and the same thing happens at their sides, *c c*, Fig. 55, and *b b*, Fig. 52, where running close to one another, they unite and become one Vessel.

THIS is the vascular construction of the Blea, and it is in the highest degree singular; for by this means its whole substance is, in a manner, one mass. The Juices passing along many Vessels, as if they were but one; and the disposition of these at the same regular distances, Fig. 55, *c c*, throughout the whole substance of the Blea, makes them form a system of regular tubes, lined with their own Membranes; which appear as so many large Vessels, and have, in some degree, the effect and office of such in the Plant.

To know the construction of the outer surface of the body of the Blea, or that which lies close to the inner Rind, it will be proper to apply larger magnifiers, and to work the fragment 51, with a pencil in water, till we in some degree get it to pieces. Fig. 52 represents a view of such a piece, in which I succeeded so far as to separate and push back the outer Membrane; and by that means obtained a better view of the Vessels. The Membrane, *c*, is thick, but colourless; and it forms a very perfect and entire coat to the Blea. This is continued also inward, in several portions, always double, and surrounding all the Vessels; and it is this which makes the Cells between the several arrangements of Vessels; which Cells have themselves been generally considered as the Vessels of the Plant.

THIS inward structure of the compleat body of the Blea is very singular. Every series of Vessels is wrapt up in a double Membrane; and the places where they are most plainly distinguished, is where they join.

WE have seen how the inward Rind is connected with the Blea; we are to see in what manner the Blea is united to, or how it communicates with the substance next within it; this is the Vascular Series. It is easily distinguished by its greener colour, and by the smallness of the Vessels.

NATURE in this observes a gradation, as if the change from the wide cells formed by the arrangement of the Vessels of the Blea, to the single course of these small ones, were too great and violent: as the Blea runs more inward, that is, as it approaches this Vascular Series, they become smaller, the Vessels also which compose them, become themselves less, till the two or three innermost parcels are mere threads. Close within these lies the Vascular Series, of which we are to speak in the next chapter; and the inner range of the cells of the Blea sticks closely to it.

To understand this union, they must be torn asunder gently, and only in part. To this purpose cut a transverse section of the Stalk near the ground, and then cut out of this a small piece from the surface to the Pith: fasten the piece upon a flat cork, with a fine needle in a handle, and with one of the crooked needles take hold upon the Rinds, draw them away, and they will come off together. In the same manner lay good hold upon the Blea, and gently draw it away. The connection between the Blea and the Vascular Series, is stronger than between the several parts of the Blea itself: therefore the substance of the Blea will be very apt to break instead of separating from this matter within it; but by care it may be got fairly asunder.

A PIECE of the two substances which I was so happy to separate in this manner, is represented at Plate V. Fig. 53. Where the separation being absolute between the anterior part of the two substances, while they yet remain fixed together behind, we see the nature of their connection. In this Figure *a* represents the Blea; and *b* the Vascular Series, of whose composition we shall speak presently.

FROM those parts of the Vessels of the Blea where they cross one another, there rise small oval Vesicles; the broad ends of these rise from the Vessels of the Blea, and the smaller ends always fixed to some part of one of the Vessels of this Vascular Series. They pierce the Membranes on each part, and hold the two substances together, at the same time that they make a communication between them.

A PIECE of the inner surface of the Blea is represented at Fig. 54, vastly magnified, to shew the origin and place of these Vesicles; and one of the Vessels itself at 56. This kind of union is kept up between the innermost coat of the Blea and the Vascular Series throughout the whole Plant.

C H A P. XX.

Of the V A S C U L A R S E R I E S.

THE fourth substance of the Plant, whose thinness had occasioned its being hitherto overlooked, is the Vascular Series. This, in the Hellebore and most other species, is a single course of Vessels, lodged between two Membranes; a slight view of which we have given at Fig. 53, Letter *b*; and a more distinct one at 57, and the succeeding Figures.

WHATEVER part of the Plant we examine, excepting the Footstalks of the Leaves, we find this substance. It lies close upon the Flesh every where, and seems pressed between that and the Blea. Its course in the entire Plant is represented at Fig. 57. We are to consider the object of this Figure as the same Plant of Hellebore with which we began: that is, a single Root torne from the entire Cluster, represented Plate I. with an ascending flowering Stalk and one Fibre. This we represented split in Plate II. Fig. 24, with the outer Bark thrown off: in Plate III. the inner Rind is separated in the same manner; and has taken with it the two outer Petals: in Plate IV. Fig. 50. the same Plant is stripped of its Blea, which takes with it the three inner Petals; so that in the present Figure 57, the Plant is reduced to the covering of the Vascular Series, which is here represented as laid back from the Flesh; and the ascending Stalk cut off within it, to prevent confusion.

THUS we can trace the course of this singular part of the Vegetable Structure entire. If we follow it from *a*, in the body of the Root, downwards, we find it coating the Flesh of the Fibres at *b b*, returning round their ends at *c c*; and having ascended over the whole body of the Root, proceeding upwards in a continued substance to coat the Flesh of the Stalk at *d d*; and finally terminating in the Flower; there forming those wonderful bodies the Nectaria. This is its place, and this its course in the entire Plant. Its office is to feed those tubular bodies in which it terminates; we see nothing of it in the Footstalks of the Leaves, because no such bodies are to be found, except in the Flower.

C H A P. XXI.

The CONSTRUCTION of the VASCULAR SERIES.

WE have examined complex objects hitherto: this is extremely simple. When we view it in a transverse section of any part of the Plant, it scarce appears unless to the great magnifiers; and then as a dotted line only, surrounding the Flesh, and separating it from the Blea. See Plate III. Fig. 25, *a*. But the other coats of the Plant being taken off by maceration, it is easy to raise and loosen small pieces of this. A bit thus separated, washed clean, and laid in water before the Microscope, appears to the common magnifying powers only as a yellowish skin, with several green cords running up it. See Plate V. Fig. 58. To shew its structure better, we must use greater powers; and treat this as the other parts, by brushing it in Water, to get the coats asunder.

A PIECE of this Vascular Series taken from the Flowering Stalk of Hellebore, near the ground, and examined with this attention, shews perfectly the structure of the part. The Vessels are found to be lodged between two yellowish Membranes; and we see in many places those little oval Vessels which unite the substance and the Blea with it; and elsewhere the marks of them, and the perforations of the Membrane thro' which they had passed. A piece thus magnified, appears to the great magnifiers, as Fig. 59, where *a* represents the outer Membrane, *b* the inner Membrane, and *c* the Vessels themselves between.

THESE Vessels are very differently disposed from those of the rest of the Plant; they are large, tolerably straight in their course, and, so far as I have yet seen, have no communication whatsoever one with the other.

THEY are so strong that they are more easily separated from their Membranes than any others; and I have sometimes been so happy to remove them clean from them, as at Fig. 60, with the Vesicles of communication yet adhering to them. One of those Vesicles is represented separate at 61, with the manner of its joining the Vessels of this Series.

WE have observed, that these Vessels terminate in the Nectaria of the Flower; and it is not impossible to trace them thither; though in their course through the Receptacle of the Flower, which is that fleshy head from which these and the Filaments rise, they are much less distinct than elsewhere. The first particularity that occurs, is, that these Nectaria are

only twelve; whereas the Vessels of this Series are at least ten times that number: the simple course would have been, that one Vessel should have terminated in one of the Nectaria; but the Flower would then have been encumbered with Nectaria, and Nature would have omitted the final change in their Juices made in the Receptacle, in that part where they seem to lose themselves.

THE Vessels, Fig. 59, having ascended with their Membranes about them, as far as the part *ff*, in Fig. 57, there form a wonderful plexus one with another in the body of the Receptacle. This Receptacle has its place just where the Petals begin to expand, and it is formed principally of that white substance which surrounds the Conic Clusters; of which we are to speak in a succeeding chapter. From this fleshy lump rise the Filaments as well as the Nectaria, and even the inner Petals are connected with it at their base; its shape is oval, and the broad part is downwards. When we cut it thro' longitudinally we see its Coat thick, and when transversely, the appearance is much the same. The white substance surrounding the Conic Clusters is spongy; and here, where it swells into a kind of head, its texture becomes more compact. Two views of it in the longitudinal and transverse sections, are represented at Fig. 62, 63. To examine it more regularly, the proper method is to cut off a thin piece, together with one of the Filaments, and one of the Nectaria. Pursuing the stroke carefully downward, we shall not fail to bring away a part of the Vascular Series: this we are to wash carefully with a fine pencil, and we shall then have the absolute continuation of these Vessels into the Nectaria before us.

SUCH a piece is represented at Fig. 64, with the Nectarium and Filament enlarged. All we see in this power of magnifying is, that between the base of the Nectarium, *a*, and the top of the Vessels *b*, there is a substance unlike to either of them, in which the Vessels seem to terminate, and from which the Nectarium seems to rise, as also the Filament. There requires more power of magnifying to see what course they take distinctly. With a larger power we distinguish, that the Vessels enter this white mass, diminishing as they proceed, and gradually losing their colour; but we lose them, even in this view, in their progress. See Fig. 65, *a b*. A small piece of the white mass, 65, *c*, must be pared off with a fine knife extremely thin, and in the exact course of the Vessels; and this being laid in water before the most extreme power of the Double Microscope, we then see the Vessels gradually diminishing, and becoming paler as they run into this

this substance; and toward the surface where the Nectaria are to rise again, enlarging, and many of them uniting into one, giving rise to the Nectaria.

A VIEW of this is given at Fig. 66, in which we see the green Vessels losing their colour as they enter the body at *a*, and acquiring it again when they become exposed to the air, in their united form at *b*, rising in the new form of the Nectarium. A transverse section of a piece of the Receptacle, is represented at Fig. 67, in which the Vessels are seen uniting as they approach the surface.

ONE further observation this section offers, which is the communication between the Nectarium and the Filament; but as this is more distinctly seen when the section is made nearer the place of their rise, it is represented at Fig. 68, as it appears just under the surface. Here it is evident that several Vessels arise from the base of the Nectarium, just where the Vascular Series unites to form it, which pierce the substance of the Receptacle, just below the base of the Filament; and rising in their course plainly run up into its hollow. Thus terminates this singular, and hitherto unobserved part, the Vascular Series; forming the Nectaria, and from thence plainly delivering Juices to the tubular body of the Filament.

C H A P. XXII.

Of the FLESH of the PLANT.

THE name alone is new in this subject; the part is too distinguishable to have escaped the notice of the most slight observers. In Trees, the substance which covers the Pith is distinctly called the Wood: in Plants, there is such a substance also, covered by the Blea, and covering the Pith, but it has no peculiar name; I have called it the Flethy Substance, or the Flesh of the Plant, as it is of a firmer texture than the slight parts before described, and is of all others the most essential to the Vegetable.

PURSuing our experiments upon the pieces of the same Plant of Helibore which we had before stripped of its several Coats, and last of the Vascular Series, we now find this Flesh, and the Pith, with the conic clusters of Vessels, all that remain. The course of the Flesh in the Plant is represented at Plate VI. Fig. 69, 69, split, and turned back from the Pith. Tracing this as the others, we shall find something peculiar in its dis-

The Blea

The Vascular Series.



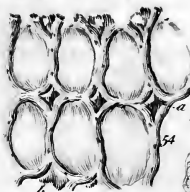
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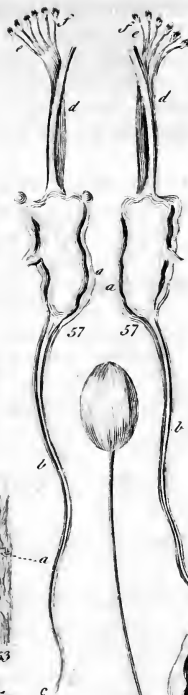
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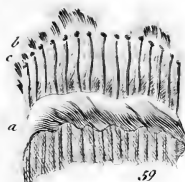


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61



62

63



66



67



68

The Blea & Vascular Series.

Series.

disposition; and shall, without much difficulty, distinguish that it has been the original portion in the system, producing not only its several Coats, but all the parts.

IN the body of the Root we see this is a massy substance, forming the entire circumference of that body, and sending upwards portions from its outer surface, to form the Flesh of the Stalk, and downwards for the Fibres. This has been explained at large in the Anatomy of the Root, in Plates II. and III. We see it very distinctly in a Plant thus managed, and cannot but observe a vast difference between the course of this part and the others: the Coats of the Stalks and Fibres are plain continuations of the Coats of the body of the Root; but the Flesh of the Stalks and Fibres are not continuations of the Flesh of that body, but only productions of it. This Flesh thus becomes a part also of the entire Plant, rounding the ends of the Fibres and their heads, in the same manner rounding the body of the Root, and in a process thence running up the Stalk, where it does not return upon itself, but when it has reached the Flower, divides, and forms the Filaments, 69, *a a*, tho' not without the intermediation of the Receptacle.

THERE the several Vessels of the Flesh of the Plant lose themselves in the spongy substance formed by the Coat of the Conic Clusters, and rising again from its upper surface, diverge into the Filaments.

C H A P. XXIII.

Of the CONSTRUCTION of the FLESH, or FLESHY SUBSTANCE.

WE enter now upon the most important examination in the Vegetable Anatomy: This is a part the most essential to the Plant of all; indeed, the only part which is essential; yet it has been hitherto the least understood.

THE other parts of the Vegetable Structure, are one or other of them wanting in various Plants, or various Parts of Plants; and we see the system can exist, and enjoy its species of life without them: they, therefore, are not essential. But no Plant, nor any necessary part of a Plant, is ever found without this substance: therefore it is essential, and alone essential to the Vegetable Life.

It is, indeed, the only part wherein is immediate Growth, and is itself capable of producing all the others. It will live alone: but all the others cannot live without it. It will produce them all: but none of them can produce it. If the Pith be scooped away in one Plant, and the Coats taken off in certain parts of others, this Fleishy Substance will shoot a new Pith inward, in the one case, and new Coats, even all of them, in the other: but if ever so small a portion of this be taken away, it never is restored.

It is universal in the Plant, whereas others terminate in particular places; and it produces all the rest. The Filaments in the Flower, which are the essential part in the production of new Plants, are continuations of it: and as the Seed Vessels are portions of the Pith which it shoots inward, so are the Petals and Nectaria of the Rind, Blea, and the Vascular Series, which this part sends outward.

It covers the Pith every where, and returns upon itself in several places: for tho' it is found in every part of the Plant, it is not entire every where. The Root, we see, has a regular case of it, independant of the Stalk: and it is a part of the surface of this case only which rises occasionally, as the seasons call it, into the Stalks. These have a connected portion of it during their vigour; but in the Body and Fibres of the Root it exists perfect and independent of them: therefore the Root has Vegetative Life when no Stalk rises from it; possessing also the Flavour and the Virtues.

SUCH is the importance of this part, that it properly constitutes the character of the Vegetable System, distinguishing that great arrangement of Beings from the two other kingdoms. Nature has impressed indelible and invariable marks of this distinction, if men would have observed them. The characteristic of an Animal Body, we have shewn, is the having a system of Nerves; the character of a Vegetable Body is, the having this Fleishy Substance: Sensation arises from the Nerves of Animals; and growth from this part in Plants. Such is its importance; let us trace now its structure.

It is the original Plantule in the Seed; it swells into the body of a Root when that Seed is sown, shooting a Blea and two Rinds outwards, and a Pith inwards. Thence it is continued in a new growth downward into Fibres, rounding their ends as an arch, and upwards into a Stalk. But in the body of the Root it is entire: the Pith there is surrounded by a plain and regular Coat of it; and tho' the Stalks and Fibres rise from it, yet its whole substance is not continued into them.

WHEREVER

WHEREVER a Fibre is to be produced, a portion of the surface of this Fleſhy Subſtance riſes in a Blifter, and forcing its way outward, takes the Coats with it. The courſe of the Fleſhy Subſtance itſelf is not altered by this; only a portion is raiſed from it. Thus it is entire in itſelf; and thus all the parts of a Plant are produced by it.

It is extremely difficult to know its ſtructure, for the great quantity of matter in it renders it opaque. Sections cut tranſverſely from a Fibre, ſhew it beſt; but when the other parts are cleared away, the Vaſcular Series, and Conic Cluſters, remain fixed firmly to it; itſelf appearing of a woody ſubſtance. See Plate VI. Fig. 70, where *a* is the Fleſhy Subſtance, *b* the Vaſcular Series, which ſurrounds it, and *c* the Conic Cluſters within. But in this view we diſcover very little of its own texture.

IN ſections cut from Fibres longer macerated, we ſee that it is vaſcular, as at Fig. 71; but it is not compoſed wholly of Veſſels, for there are Ribs of a ſolid Matter in the angles, which are form'd between them. We muſt go further yet to ſee it truly. A ſection of a macerated Fibre muſt be cleaned in fair water, hardened in alum-water, and then plunged in ſpirit of wine; in this it is to remain a week, and we ſhall then have it in a condition fit to be viewed.

THE Veſſels of which this Fleſhy Subſtance is compoſed, may then be eaſily ſeen in a thin tranſverſe ſection laid before the Double Microſcope, as at Fig. 72; and we ſee plainly why all was obſcure before. The Veſſels of this part do not contain a watery or colourleſs liquor, as thoſe of the others; but the eſſential Juice of the Plant: whereon depend its taſte, ſmell, and virtues. All theſe are, in a manner, centered in this, and in thoſe proceſſes of it which run in amongſt the Blea; theſe uſually break off in ſeparating this ſubſtance from the reſt; therefore they are not figured here. This Juice is thick, and coloured, and ſo ſlowly leaves the Veſſels, even in the thinnest ſections, that the tops of them continue covered over, and the interſtices as well as their cavities filled with it; ſo that all appears one opaque maſs.

WHEN a ſoft water has penetrated this Juice, and a ſolution of alum hardened the coats of the Veſſels which contain it, ſpirit of wine, without affecting them, will, in a great meaſure, diſſolve, and abſorb it; then the Veſſels appear diſtinctly, as in Fig. 72. They are round, they have large cavities, their Coats are ſupported by woody Fibres, and cluſters of the like Fibres run up in all the ſpaces which thoſe round bodies leave in touching one another. Theſe are larger than in the other parts of the

Plant; where the Vessels themselves being weak, press more upon one another.

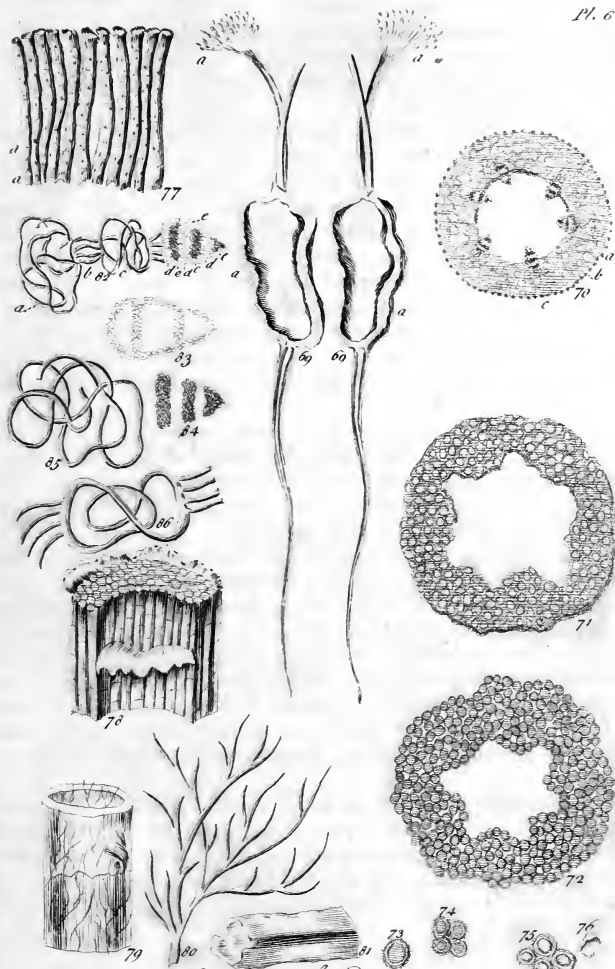
At Fig. 73, is represented the mouth of one Vessel, with the ends of the woody Fibres. At 74, a space filled with the woody matter: at 75 the same space empty; and at 76 the substance which filled it; which is shewn also greatly enlarged at 81.

In a longitudinal section treated the same way, we see the Vessels plainly and distinctly in their course: they are jointed, as it were, at certain distances, but not cut or pinched in at those Joints. The Vessel keeps on its course; only there is a Valve at every Joint. This does not open in the center, but is loose for a small space on one side, where it is capable of being raised a little, but not of falling inwards or downwards. One Bed of these Vessels is represented at 77; and a piece of the whole thickness, consisting of five Coats covered with two Membranes, at 78: a piece of one Vessel, with its Valve vastly magnified, at 79; and the woody Fibres which support it at 80. This part is connected to the Vascular Series by small oval Vesicles or Glands; as that is to the Blea. See 77, *a a*.

THESE are minute researches, but they are important. Juices may ascend these Vessels, but it is impossible they should descend thro' them: or they may pass in a regular course one way, but not return back. The woody Fibres which run up between these, have also a small hollow; but the Juice in this is not coloured, as in the Vessels.

THIS is the construction of the Flesh: its course we have shewn thro' the whole Plant. When it has made a compleat Circle, or Coat in the Root, it sends up a portion of itself, which forms the Flethy Substance in the Stalk; and this at the Head, when the Rinds and Blea have left it, going off in Fibres and Petals, swells into a somewhat thicker substance, arched inwards, and there acquires a strong green. The woody Fibres terminate in this swoln extremity; and every Vessel makes a kind of Gland, winding about itself in various forms, and shooting forth from the whole upper surface of the arch a new Pith; as this Flethy Substance readily does in other places.

THIS Pith is covered only with an extremely thin portion of the Flethy Substance, and this breaks away upward into numerous double Threads, which are the Filaments. These acquire a Coat or Skin, as that substance does whenever it is exposed to the air: but then, tho' divested of its Coat, it is still in the body of the Flower sheltered from the weather by the Petals;



Construction of the Flesh?

EXHIBIT 10

Petals ; and therefore this Coat is white. The termination of each of these pairs of Fibres or Threads, which are inclosed in the white Membrane, is in a globule of an oval form : the two are placed near one another within the common Membrane ; and thence the Anthera is double. In each globule of the Farina there is a minute portion of the Flešhy substance turned round upon itself, the end being too weak to pierce the shell of the globule. These are the original *Plantulæ Seminales*, which being covered by the waxey matter obtained from the *Nectaria*, and afterwards lodged in the Seeds, grow into perfect Plants.

C H A P. XXIV.

Of the COURSE and STRUCTURE of the PYRAMIDAL CLUSTERS.

THE Clusters of Vessels which have been described, as having their place within the Flešhy Substance in every part of the Plant, come next to be examined. Tho' they are in some degree immersed in it, they are no absolute part of it: they are a distinct system; and they consist of certain arrangements of colour'd Vessels covered and separated by white and pellucid ones. We have seen these in the various sections of the Plant, whether we cut the Fibre, the body of the Root, or the parts above the surface. They are not peculiar to the Flower Stalks, for we find them also in those of the Leaves: therefore they are not destined to become organs of fructification; but are nutritious Vessels only: and they are universal in the Plant.

It is in the body of the Root we are to look for their origin; and there we find them produced from the coloured Vessels of the Flešhy Substance.

In certain places these form a kind of knots. See Plate VI. Fig. 70, Letter c. One of these, separated and more enlarged, is also represented at Plate VI. Fig. 82. From these knots, 82, *a*, run little Fibrils, *b*, which are so many real Vessels, and in which we can see in the fresh Plant a coloured Fluid: these, at a small distance, form new knots, Fig. 82, *c*, from whence proceed the several coloured Vessels of these Clusters, Fig. 82, *d d d*; and from their own sides are produced, in the same manner, those pellucid Vessels which surround them, Fig. 82, *e e e*. At 83 is represented

sented the white part of the Cluster separated ; and at 84 the green. At 85 the original Knot ; and at 86 the Vessels running thence, and producing the second.

THE whole Cluster is pyramidal, when it is perfect : and might appear to the incurious only one Vessel, 70, *c*. It has been shewn how the Cluster consists of many ; and it is for this cause that in maceration, or even in a diseased state of the Plant, the Clusters often break, and separate.

C H A P. XXV.

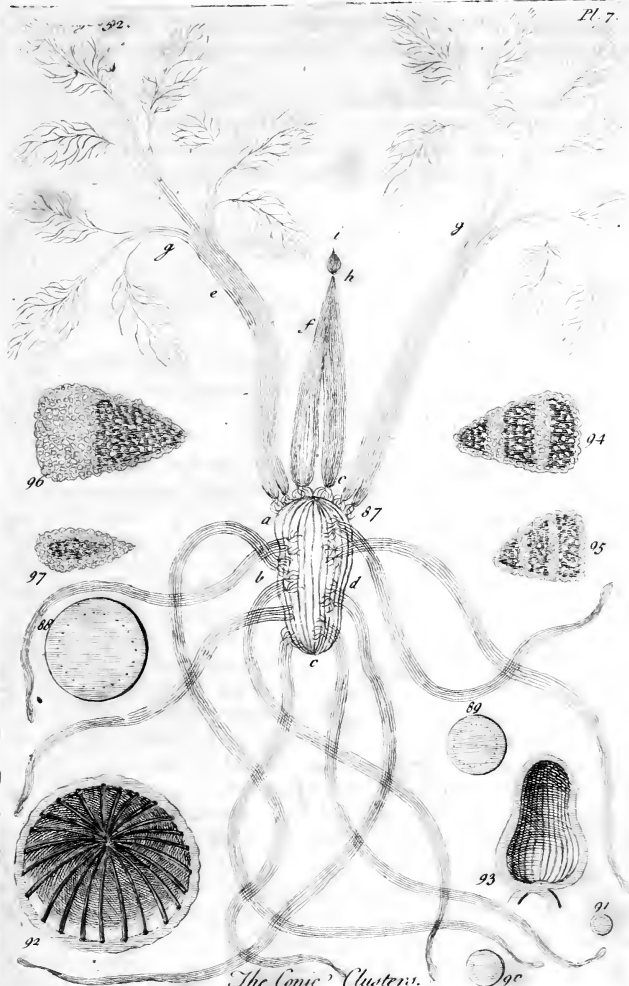
The COURSE of the PYRAMIDAL CLUSTERS.

IF we pursue the course of the several Clusters, we find them exhibiting, in the macerated parts, a kind of Skeleton of the Plant ; if that name may be given to things so little solid. This is represented in Plate VII. Fig. 87.

THERE are twelve of these Clusters in the body of the Root, *a* ; and six in every Fibre, *b*. The twelve in the body return upon themselves at the crown, and at the base, *cc* ; and the six in each Fibre are not continuations of these. The Flethy Substance comes between, and they are produced from its surface in the Fibre, just as they were in the body of the Root ; but communicate with those of the Root, by the minute Vessels *d*. They round its end as they did the base of the body ; and return into themselves at the crown : so that in strictness the six are only three, and the twelve only six. They are counted double, because we see them going and returning. In each Footstalk of the Leaf there are twelve of them, *ee* ; and in the Stem of the Flower twenty-four, *f*.

ALL these are produced exactly as the Clusters in the Fibres of the Root : they are not continuations of the original twelve in the body ; but are formed from the Flethy Substance of the part wherein they lie. This is peculiar in Vegetables, that one portion of their substance can produce all the others ; and it is from this reason that all the parts are capable of growth.

AT the crown of the Root these Clusters return in an arch, into themselves. The Footstalks of the Leaves divide each into three parts at the head ; from which several portions the partial Leaves grow : and in each of these are four of the Clusters, the twelve of the Stalk being regularly divided



The Conic Clusters.

divided among them, *g g*. These run up the middle Rib of each Leaf, sending off branches all the way into the side Fibres, till they have thus exhausted their whole substance.

Thus far they are like the Nerves of Animals; that they do not diminish as they come toward the extremities, otherwise than by sending off part of the Vessels which compose them. These always go off accompanied by some of the pellucid Vessels; and the Cluster diminishes only as they are sent away: for each particular Vessel is all the way of the same diameter.

IN the Flowerstalk, tho' they be distinctly four and twenty at the base, that entire number is not to be counted in sections of the upper part, for they run one into another when pressed into a narrower compass at the neck: from this part they continue themselves into the Receptacle. They come nearer together as the diameter of the Stalk diminishes at the top, *b*, and finally run up to the extreme top of the Receptacle itself, *i*.

IF we continue to cut transverse sections of the Stalk upwards 'till we come to the Flower; and then pursue the same course, cutting thro' the Flower and Receptacle transversely, by a multitude of very thin sections, we by degrees see the two outer Petals, then the three inner ones, fall off; and when nothing remains but the Nectaria, Filaments, and Seed Vessels, still every section presents these Vessels very distinctly. See Fig. 88, 89, 90, 91, representing these various sections. Tho' they were crowded together in the neck of the Stalk, they were never confounded in their substance; they separate again in the Receptacle, and the fleshy part of that being white, and these Vessels dark, we see the full number of twenty-four very distinctly. Even when the Filaments are all fallen off, and the remainder of the Plant is only the collection of Seed Vessels, these twenty-four Clusters, tho' very minute, are still perfectly to be discerned; and in the section which gives the very summit, where the Seed Vessels disunite and fall off, these Vessels are seen returning in so many arches upon themselves, and continuing their course down toward the Stalk. See Fig. 92. Their course upward in the Receptacle is also shewn at 93.

As the disposition of the green and white Vessels in these Clusters differs in the several parts, they are represented distinctly in this Plate: Fig. 94 is the Cluster in the Flowerstalk; 95 in the body of the Root; 96 in the Footstalk of the Leaf; and 97 in the divisions of that Footstalk.

C H A P. XXVI.

Of the P I T H.

EVERY thing being now cleared off from the macerated Plant, there remains only the Pith; a substance which has been thought very important, but which a more critical enquiry robs, in a great measure, of that character. Its disposition and course in the entire Plant, is represented in Plate VIII. Fig. 98.

WHATEVER perfect part of the Plant we cut, we see this: it always occupies the center; but it no where reaches the extremity of the part wherein it lies. In the Fibres it is a column, which goes very gradually diminishing from the larger to the smaller end, *a a*. But it neither reaches the body of the root, nor the extremity of the Fibre. We have shewn how it lies in the head which makes the end of the Fibre: at the part near the body of the Root it is terminated in the same manner: the Vascular Series and Fleishy Substance in each of those parts surround it.

IN the Body of the Root there is another column of Pith, *b b*, if it may be so called; but this is very irregular at the sides; and this is in the same way terminated by the arch which the Fleishy Substance makes at the base and crown, and by the Vascular Series. This Pith of the body of the Root has no connection whatever with that in the Fibres.

IN the Footstalks of Leaves there is no Pith. The Leaves are not perfect parts, but assistant organs.

IN the Flowerstalk it forms another column, *c c*; largest at the base, and smallest at the neck, where it is pinched in at the origin of the Flower, and there is again finally terminated. But tracing the Plant up into the Receptacle, we see there another column of it, *d d*, short, and in form of a cone, with a broad base running suddenly to a point. This has no more communication with the Pith of the Stalk than that has with that of the Root. All the Parts of the Plant have a Pith; but it is detached in each: and, therefore, in representing that of the entire Plant, we must place it in order, in four disjointed pieces. The termination of the uppermost of all is just under the arch made by the Clusters of Vessels at the summit of the Receptacle.

HAVING seen its course and place, we are next to consider its construction.

It is plainly formed by juices thrown out from the inner surface of the Fleſhy Substance of the Plant, and from the ſurfaces of the ſeveral Conic Cluſters of Veſſels. Theſe Juices hardening on thoſe ſurfaces form Veſſels. Thus the Pith becomes Vaſcular: and as only the ſurfaces of theſe vaſcular Cones, and the intermediate inner ſurface of the Fleſhy Substance give it origin, it muſt of neceſſity be circumscribed within the bounds of the hollow which they form. Thus it is utterly impoſſible the Pith of one part ſhould run into the Pith of another: and what at firſt appeared ſo ſtrange in its courſe, is the neceſſary reſult of its conſtruction. A tranſverſe ſection of the Pith of a Fibre of the Root, cleared from all the other ſubſtances, is repreſented at Fig. 99; and a like ſection of the Pith of the Flower Stalk, at 100. The mouths of the cells are empty or full of Juice as the knife has chanced to paſs thro' an empty or a full part.

THE Veſſels of the Pith being covered the moſt of any in the Plant, from the air, become thence the whitest and moſt tender. They are very numerous, and are jointed in a manner at once ſingular and highly elegant, Fig. 101. The Cells are of nearly an equal length and thickneſs; ſo that the joints are ſhorter than in the Blea, whoſe Cells they otherwiſe, in ſome degree, reſemble: but there are no Veſſels upon them. The Blea conſiſts of Cells and Veſſels; this part of Cells alone. The diviſion between Cell and Cell are of a ſpongy Membrane, full of ſmall holes, which are ſhewn at Fig. 102, a little more magnified. Through theſe the liquor forces itſelf in little drops, ſo that the whole Veſſels often appear full as it were of ſtrings of minute beads.

THESE Veſſels ariſe principally from the part of the ſurface of Fleſhy Substance which makes the arch at the baſe of that portion of the Plant wherein they are formed. See Fig. 103, *ab*; and from the arches of the conic Veſſels there. From this part they run to the arch at the top in a tolerably ſtrait courſe; and there are again inſerted in the arches of the ſame parts. Some Veſſels of a like kind and form, and which make a part of the ſame ſubſtance of the Pith, are alſo ſent off from the ſides of the hollow Cone formed by the inner ſurface of the Fleſh, and Conic Cluſters; and theſe in the ſame manner run ſtrait upwards, and terminate in the arch at the top. Fig. 104 repreſents a ſmall piece of the Pith, with the Veſſels greatly magnified, to ſhew the courſe of the chained globules of Juice: at 105 is a piece of the ſingle Veſſel viewed with the greateſt magnifiers, with the Membrane ſeparating it into Cells: and this Membrane, with its irregular apertures, at 106.

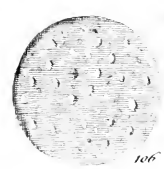
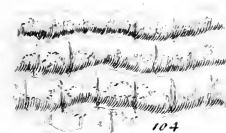
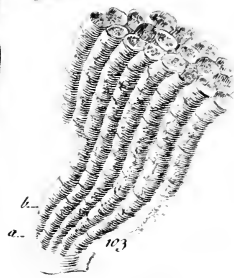
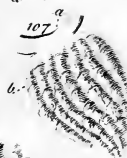
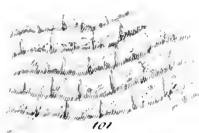
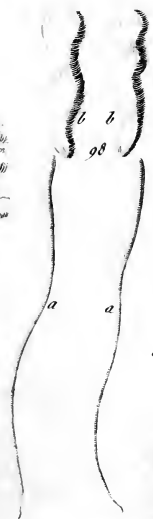
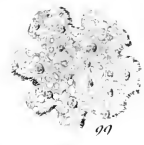
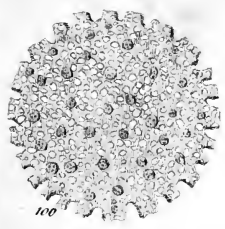
THE most extraordinary part of the Pith is that in the Receptacle, Fig. 107, 107. Close under this, that is, at the head of the Flower Stalk, the Flethy Substance makes a fair arch, returning upon itself so as to stop and terminate the column of Pith within it there, 107, *a a*. From this part it sends up each way a portion of its upper surface, *b b*, which makes the Cone of the Receptacle; and within this is form'd a new Pith, with new Series of Vessels. A portion of the Pith of the Receptacle is represented separately at 108.

THE substance of the Seed Vessels is formed of the Blea which this Flethy Cone shoots out on the surface; and the Pith of the Cone begins and terminates in it.

AFTER examining, in this manner, the two Barks of the Hellebore, we continued the same course of enquiry to the like parts of other Plants: and these appeared to be, in all essential articles, the same with the first. In the same manner I have pursued the course and structure of the Blea, the Vascular Series, the Pith, and the rest, in several other Plants; and find that the generality have them all; and none have any more: their place is the same in all, and their course the same, as also is their structure. Therefore what we have seen here to be the composition and construction of the Hellebore, we have a right to believe is the Vegetable Structure in general. If there be variations in some kinds, they are slight; and the general system is not affected by them, any more than the generical characters are by specific distinctions.

IT has been thought peculiar to the Pith, in certain Trees, that it occupies a large space in their young Shoots, and shrinks so as almost to disappear, as the same parts grow more confirmed in their construction: but the present account of that part will, in some degree, explain this wonder; nor will the observation be applicable to the Pith alone.

YOUNG Shoots draw from the earth abundant moisture; for out of that is to be formed the Vegetable System: but as a great deal is for this reason taken into the Vessels of the Plant; a great deal must be also discharged from them. This is done outwardly by the Hairs or downy matter common on young Stalks; and inwardly, tho' in a less degree, by the Pith. This being the great use of those two parts, they are essential to the Plant in that state; but they become unnecessary afterwards: and therefore, in many Plants, and particularly in several Trees and Shrubs, the young Shoots have a large Pith within, and a thick downy covering on the surface; whereas, when they are grown harder, they become smooth and solid.



Construction of the Pith.

THESE observations, joined to what we have just seen of the inner structure of the substances, will teach us what parts are essential to the Vegetable System, and what only accidental; what absolute; and what merely temporary. We shall thus distinguish the importance of the several parts, and be led forward regularly in the course of our great enquiry.

C H A P. XXVII.

Of the LIFE of PLANTS.

BY Life in Plants, we mean that power whereby they grow: receiving nourishment, and advancing from the minute and tender state wherein they lay within the Seed, to height and strength; extending and disclosing regularly their several parts; and in the end forming new Seeds for a succeeding race. This power all Vegetables plainly have; nor are their instances of life limited to these alone: for some have motion in their several parts, the Sleeping and Sensitive Plants in their Leaves and Footstalks, and most of the Syngenesious Tribe in their Flowers.

THE Seat of Life I apprehend to be in that part I have called the FLESH of the Plant; and its powers to arise from a motion in the Juices of that part. This motion seems to be peculiar to its Juices, and not to have place in those of any other part of the Plant; it appears also by its several states and degrees, to give Health, Vigour, Sicknefs or Decay, to the entire Vegetable.

THAT this substance, the Flesh of Plants, is the seat of their Life, appears from these certain observations: that no Plant is destitute of it, tho' occasionally one or other of the several other parts are wanting; and that when this part is destroyed, the Plants inevitably dies: whereas, while it remains, there is always life; and there resides in it a power of producing, by the mere motion of its Juices, all the others. This we evidently see in Seeds, whose Corculum is no other than a regular piece of this substance; and tho' less obviously, yet not less certainly, in the growth of Cuttings.

THERE is no state wherein the Vessels of this part are destitute of their proper Juices: these require moisture, to make them able to flow in the Vessels, and heat to put them into motion. When they want these they coagulate in the Vessels; but they retain a long time the original power of being put in motion by those assistances. It is for this reason the heart of the

the Seed, which is a piece of the Flesh of the parent Plant, does not grow while kept out of the ground; but shoots when planted: the want of moisture prevented its growth before; for when Seeds ripen, the Vessels of the Plant which fed that part where they are formed dry up. Yet we see they are capable of growth even there, when accidents give the means: thus, in rainy seasons, the Seeds of many of the Grasses shoot in the Ear.

As Seeds are capable of being kept dry a long time, yet with the latent power of Life unhurt. So it is with those Roots which we take up at certain seasons, and may keep out of the earth, for several months, nay years. The philosophy of both is the same; for Seeds and Roots differ more in magnitude than nature. In each there is a portion of the Flesh of the original Plant, which forms a Case or Shell, defended from injuries by its outer Coverings; and has Vessels returning upon themselves, in form of the Vessels of animal bodies, tho' wanting the distinction of Arteries and Veins. The Juices in this substance may coagulate and cease to flow, and yet retain the power to do it on proper assistance: and so long the Seed or Root enjoys a state of capable, rather than actual life. The Seed is as the egg of an animal, which will never come to growth without the proper helps; tho' it will, for a certain time, retain the power of life. The Root we take out of the ground, for certain months, would remain during the same time if left in the earth in a state of rest: a condition not very unlike that of those animals which sleep the winter: Just so much Life remaining as to preserve the vegetable character; tho' without performing any of its functions.

On the circulatory motion of the Juices in these Vessels of the Flesh of Plants, depends entirely their growth, and the disclosing of their parts: yet there is not a necessity that the motion of returning Juices be carried to the extremities of all those parts. The vigour of a certain system of circulation will give growth to detached parts of the Flesh which rise far beyond it. This is seen in the formation of the Filaments in the Flowers of Plants; for there is no return of their Juices. The force of growth in them arises from a system of circulation lodged much lower in the Plant; and this system of returning Vessels, is sometimes single, sometimes repeated. This will be explained at large in the succeeding Chapters, where we shall illustrate the general doctrine by particular instances. It may be sufficient to observe here, that the Winter Aconite, to be described hereafter, shews an instance of a single circulatory system; there being no returning

turning Vessels except in the Root: and the Anemone of a double order; one in the Root, and a second in the lower part of the Stalk.

C H A P. XXVIII.

Of the FORMATION of a PLANT in the FARINA.

IT will be proved by numerous and plain facts, that the FLESH of Plants is the essential Vegetable Matter; and it has been shewn already, that the termination of this part is always in the Filaments of the Flower, upon whose summits stand the Antheræ, containing that Farina, which all know to be necessary to the impregnation of the Seed; tho' it has not been yet shewn truly in what manner.

By tracing the course of the Flesh of the Plant up to the Filaments of the larger Flowers, we find that the Vessels of this part diminishing there, run up in numerous distinct clusters to the top of each Filament. The Coat of the Filament spreads into a Vessel called the Anthera, and these clusters of Fleishy Shells line it throughout: there continuing to grow, they raise its internal surface into little Blisters all over: the Coat of the Anthera is double; and there is a spongy matter between the Membranes: these clusters of Vessels also run between the two. And they now raise the inner Coat from the outer, in form of those Blisters; which contracting at the neck where they rise, and being filled by Juices discharged into them from the Spungy Substance of the Anthera, swell; and each becomes a globule of Farina. The cluster of Vessels, or particle of the Flesh of the Plant, when it has grown so as to reach the top of the little Blister, not having strength to pierce it, is bent round, and continues to grow till its extremity meets the part where the cluster entered the globule: All is naked, tender, and delicate here; the Vessels as they meet inosculate, and there is thus formed an oval ring of the Flesh of the Plant, containing many of its Vessels, returning into themselves.

THIS is the rudiment of the future Plant. These Vessels have their Juices, and they form a small system, containing all that is essential to the species, capable of preserving themselves dry; capable also of growing with the help of heat and moisture; and capable of producing all the other parts, and forming an entire Plant of the same kind; the extremities of whose Flesh Vessels shall form again such other systems; and this with-

out end. This is plainly the manner of Vegetable Production and Increase : there is no Generation, but simply a continued Growth.

As soon as this little system of vascular Flesh is formed, the intent of Nature in the parent Plant is answered in that part. The Juices from the spongy substance of the Anthera are derived from the Vessels of the Nectaria; and are of the nature of wax : they surround this little system ; they defend it from injuries ; and the Anthera then dries, and bursts open ; the little globules of Farina drop off from the inner Coat of it, their small necks having dried away : and thus the globule falls off upon the Stigma of the Flower. That part is always wet ; the thin skin of the globule bursts, and the Plantule, or piece of vascular Flesh, falls out, encompassed with this waxy matter, which, not mixing with the water, appears like solid atoms.

SURROUNDED by this indissoluble matter, the ring of Flesh makes its way into the Seed-Vessel ; where there is always an open way for it into a Seed : the same opening at which the young Plant afterwards bursts forth ; and which is always visible. The Seed, which is formed of the Pith of the Plant, surrounded with its Coats, was originally an exudation of this very Flethy Substance, its Juices therefore are happily suited for the nourishment of this minute particle of the Flesh ; and it is no sooner lodged in the Seed, than it begins a peculiar kind of growth. There is moisture ; and there is warmth enough in the air. The Juices in the Vessels of this Ring have never yet congealed : they move ; and it must be circularly, for their valves admit of no return. Their tender coats receive, thro' the small apertures of their yet spongy substance, abundance of this appropriated fluid, they swell till the ring almost closes, being pressed together : and the same open texture of their Coats gives way to extravasation. A few loose threads of Pith are shot inward, and Conic Clusters soon appear.

THE origin of these is in a horizontal direction ; but they soon ascend ; the Juices get coats as they rise, by the mere hardening of the superficial part, and they return upon themselves, because they are too weak to pierce the Flesh where it makes the arch of the ring. Vessels are added to Vessels, by the growth of the Flesh ; and thus what was a ring becomes a shell, and is the shell or coat of Flesh of the succeeding Root, which shoots next its two SEED-LEAVES.

ALTHO' the Conic Clusters do not, in their own Vessels, pierce the Flesh, there rise from them those tender hollow threads of communication which we have seen in the preceding Figures ; and from the extremities
of

of these, where they pierce the Flesh, arise new Conic Clusters, which do not form returning systems, but spread themselves thro' the substance of the Seed in the rudiments of the Seed-Leaves. These have been taken for a peculiar system of Roots.

THE inner substances being thus formed, and still redundant Juice supplied to the Plantule, its extravasated Juices first form the Vascular Series. There remains some of the waxy matter of the Anthera among the proper Juices of the Flesh-Vessels; and this being most unlike the rest, is first thrown out: it is pushed forth with some violence; it continues to follow the course of the Plantule, and conforming itself to its shape, and the several streams hardening at the surface, the Vascular Series is formed: the two Membranes being only extensions of the substance of the Coats of these Vessels, reaching from one to the other, and keeping all together.

THE waxy fluid being separated, the next which is extravasated forms in the same manner the Vessels of the Blea; and the extravasations from these give origin to the Vessels of the two Rinds. Thus is there lodged within the body of the Seed, a piece of the essential substance, or Flesh of the original Plant, which has there formed for itself, by the natural course of the Juices, all its coverings. The purpose of Nature being so far answered, in the common state of things, no more is done there. The Juices of the Stalk cease to flow into the Seed-Vessel, the Seeds harden, and they are fit for sowing. Every one containing a perfect portion of all the substances of the future Plant, needs only due warmth, and that moisture it no longer receives from the Seed, to continue growing.

THUS far all Vegetable Nature, so far as I have examined, is regular; the formation of the Plantule in the globule of Farina, being alike in all: but it is not so in the succeeding periods, for Seeds differ in the construction and arrangement of that pulpy matter in which the Plant is lodged; and, therefore, while the generality rise with two Seed-Leaves, as the Turnip, some have only one, as the Corn and Grass kinds; and others have several, as the Pine. Therefore it will be necessary, in tracing the Seed to the Plant, to fix upon one instance, and the more common the Plant be the better. I have chosen the Radish, because its Seed is always at hand, because it very readily grows, and because the parts of the entire Plant are large and conspicuous.

To trace the whole progress of Vegetation, I shall take this instance; in which, howsoever minute the researches may appear, it will be easy for every one to follow them: and, to leave no part unconsidered, it will be best first to consider the Plant perfect, and in flower; to trace the formation

tion of a globule of Farina from that Plant ; and following the course of Nature, to observe the whole progress of that Farina to a perfect Plant again.

THE formation of the Farina of the Radish, is represented in the annexed Plate ; and will serve happily to illustrate the general doctrine just laid down, by a familiar instance.

C H A P. XXIX.

The FORMATION of the new PLANT in the FARINA of a RADISH.

THE common Garden Radish, in its full growth, is represented Plate IX. Fig. 1. The Stem of this is composed as the Stalks of other Plants, of the seven constituent substances before described ; and their proportion in this species is shewn in a transverse section of the Stalk, Fig. 2, cut from the part near the ground. They have the same disposition in the Footstalk of the Flower, Fig. 3 ; and at the summit of that Footstalk they separate one from another, to form those parts of the Flower which are their natural terminations.

A FLOWER of the Radish is represented at Fig. 4, enlarged by the Microscope, to shew the several parts distinctly ; and at Fig. 5 the same Flower, with its Footstalk, cut open, and torn from the top into its several parts, to shew how they go off from one another. The Letters *a b c d e f g*, mark the seven constituent parts ; *a* the outer Bark ; *b* the inner Rind ; *c* the Blea ; *d* the Vascular Series ; *e* the Flesh ; *f* the Conic Clusters ; and *g* the Pith. These terminate distinctly in the several parts of the Flower.

WE see, at Fig. 4, that the entire Flower has its Cup *b*, two outer Petals *i i*, and two inner Petals *k k*. Within these we see the six Filaments ; four of which are longer, and two shorter, *n n*, crowned with their Antheræ ; and in the midst of those the top of the young Seed-Vessels *o*. The same parts are more distinctly shewn in the divided Flower *p* ; and there we see also two other parts, which could not be distinguished in the entire one ; because they are hid within the other parts : these are four protuberances within the Cup, and the Receptacle of the Flower. The four protuberances are thus arranged ; two stand between the rudiment of the Seed-Vessel

Vessel and the two shorter Filaments, *l l*, 1; and the other two protuberances between the longer Filaments and the cup; these are marked *l l*, 2. The Receptacle *m m*, is a conic, whitish, spongy, body, rising from the crown or summit of the Footstalk, and affording a kind of base to the internal parts.

WE see thus there are seven parts in this Flower as in others, arising from the seven constituent substances of the Stalk; and they are produced from them in this manner.

THE outer Bark, Fig. 5, *a*, forms the entire Cup *b*, which being carefully pulled off, takes that Bark with it; the inner Rind, *b*, spreads into the two outer Petals *i i*; the Blea, *c*, forms the two inner, *k k*; the Vascular Series, *d*, terminates in the four protuberances in the Cup *l l*; the Flesh of the Plant, *e*, splits into the Filaments *n n*; the Conic Clusters of the Vessels form the Receptacle, *m m*; and the Pith, *g*, runs up into the rudiment of the Seed-Vessel *o*.

OF all these parts the most essential are the Filaments. We have seen that the Flesh is the seat of Life in the Plant; and these being the terminations of that substance, have the same quality: every piece of them, if it can be preserved from decay, is ready to grow into an intire Plant; for it can produce its lining of Pith, and all its coverings, from the extravasation of its own Juices; and as its substance will naturally terminate in other Filaments, these its coverings will form the several parts of the Flower for their defence, and the Seed for their reception.

THE Receptacle of the Flower, separated from the other parts, is represented at Fig. 6, as it appears enlarged by the Microscope. This is a kind of great Gland. It is formed of the white spongy matter of the Conic Clusters, united into one mass; and it is in this the Flesh of the Plant begins to contract its Vessels, to diminish the intermediate spongy matter, and to divide itself into Clusters. See Fig. 7: where this is, in some degree, represented in the split Receptacle, tho' it is difficult to shew it distinctly. Into this Receptacle also are sent certain white very small Vessels, filled with a pale yellowish matter from the protuberances, Fig. 5, *l l*, which terminate the Vascular Series.

THE Vascular Substance of the Flesh of the Plant, being now divested of the intermediate sponge, divides at the surface of the Receptacle Fig. 6, 7, *p p p p*, into a number of detached parcels, which may now be considered as so many clusters of pure Vessels continued from the Flesh of the Stalk, but greatly diminished: these rising again, at the surface of the Receptacle, become extended into long, slender bodies, called the Filaments;

and

and as they do not pierce the skin of the Receptacle, but raise a portion of its soft substance with them, they grow up covered with this as a skin.

Thus is formed the Filament, Fig. 8, which consists of a quantity of the Flesh of the Plant, purely vascular, covered with a reticulated loose skin, which is part of the white matter of the Conic Clusters raised into the Receptacle.

Thus is formed the Filament; and into its base run those fine Vessels which we see arise from the protuberances terminating the Vascular Series; and running thro' the Flesh of the Receptacle they go up the very substance of the Filament, and accompany its Vessels to the extremity. The substance of the Filament is to form the embryo Plant; and the waxy Juice in these Vessels is to cover and defend it. An unripe Filament is represented at Fig. 9. In the ripe Filaments we find the summit formed into a regular oblong Anthera, composed of two cylindric tubes, each with its proper groove for bursting, and fastened to the tender top of the Filament toward its lower end, Fig. 10.

THE Anthera is thus formed. Toward the summit the Filament becomes small, and at its very point there is another minute Gland, somewhat opake in hue, and full of clustering Vessels. This is represented vastly magnified at Fig. 11. A small cord surrounds it, formed of the thickened coat of the Filament; and within, all the clusters of Flesh Vessels become again much smaller. They are here at their extreme fineness. From the summit of this, Fig. 11. the coat of the Filament expands, and grows from the cord, 2, each way into a cylindric tube; and these two tubes form the compleat Anthera, Fig. 12. which tho' understood to be only fixed upon the Filament, is in reality its proper termination. The Figure at 12 represents the Anthera ripe, but entire: that at 16, shews it burst for the discharge of the Farina: the intermediate Figures, 13, 14, 15, shew its progress from the Bud of the Flower to ripeness.

THE outer surface of these two cylinders which compose the Anthera, is all we have yet seen. It will be proper to cut one of them asunder transversely, to examine their construction. This gives us a view of the inside of the cylinders, which, according to the age of the Anthera, or its degree of ripeness, appear in different conditions. In a very young one, taken out of a small Bud or Flower, the coat of the Anthera is seen to be double, with Vessels between, Fig. 17, and with a small hollow. In one yet more advanced, Fig. 18, there appear Blisters in the cavity. In one yet nearer maturity, Fig. 19, these Blisters shew a regular elliptical shape, and are so raised from the surface as to fill all the cavity. These Blisters

are

are now globules of Farina. To know how they are formed, we must open one of the Antheræ in a state of half ripeness, and then of perfect maturity.

WHEN we open in this manner a half-ripe Anthera, we find that between the two Membranes of the cylinder there run innumerable little clusters of the Flesh Vessels; that is so many portions of the Flesh of the Plant, divested of all encumbering matter, and formed of Vessels wonderfully reduced in size. All these are regular portions of the Flesh of the Plant, which have passed thro' the Receptacle, and have been again reduced in size at the top of the Filament, but which are yet entire, and contain, minute as they are, their proper Juices, and continue to grow.

IN the half-ripe Anthera we find these little portions of the Flesh of the Plant, every where striking inward toward the cavity of the Cylinder; and raising the inner Membrane into Blisters. See Fig. 20.

IN the perfectly ripe Anthera the appearance is the same, only that the Blisters are innumerable, and are larger; contracted at the neck, and ready to fall loose into the cavity of the Cylinder. This is represented at Fig. 21.

THE globules of Farina, which hitherto we have been content to call Blisters, are thus perfected. The small portion of the Flesh which has, by thrusting out its point, raised the Blister, grows a little more; but the force of Nature is so slight at this distance from the Root, that the little point of this small portion of the Flesh, tho' it continues growing, cannot pierce the Membrane formed by this Blister. Not being able to get thro' it turns backward, and by growing a little longer, forms that oval ring before described, which is properly the embryo of a new Plant. See Fig. 21. The waxy Vessels having run up all the way with these minute portions of the Flesh, terminate by plainly open mouths, where the portion of the Flesh forms the Blister, and discharge their contents into that new cavity.

THE extreme ends of the Vessels of the portion of Flesh in the globule of Farina insculcate with themselves, at the place where they touch, that is, at the base of the Blister; and the Membrane forming the Blister contracting there, and the Vessels drying for want of more nourishment, the work of Nature is so far accomplished.

THUS a piece of the Flesh of the Plant, replete with its proper Juices, and surrounded with a waxy fluid, is lodged in a little membranous bag, which, as soon as its neck grows perfectly dry, falls off from the inner surface of the Anthera, and is a globule of Farina. This contains in it a portion of the Flesh, which was the essential substance of the Plant, and

which, tho' very minute, yet if preserved from injuries, will be sure to grow when it has heat and moisture. It is defended doubly; partly by the Membrane, and partly by the waxy fluid which surrounds it. It is too tender for the earth, and is to be received first into the Seed.

THIS is the origin of a globule of Farina; which we are now to examine distinctly. To this purpose we are to take off a perfectly ripe Anthera, from its Filament, and to shake it carefully over a plate of glass, for the Double Microscope. This slight motion separates a multitude of the globules of Farina, a cluster of which we are to select for examination. They are all perfectly alike in shape; oblong, elliptic, rounded at each end, somewhat opaque, and of a whitish colour, with a darker oblong particle in the middle. This is sometimes greenish, sometimes yellowish, and is the embryo Plant; the extreme termination of the portion of the Flesh of the original Stalk, which raised that Blister: and it appears greenish or yellowish as more or less of the waxy matter covers it. On putting a drop of water to them, they swell, become shorter, rounder, and more transparent; and we perceive a small stroke in the midst of each running lengthwise from end to end. One of the Globules, as it appears dry, is represented at Fig. 22, and as it is seen in water at 23. The line is the place where the Globule adhered to the inside of the Anthera, and is the part where it opens at a proper time, to let out the embryo Plant, as at 24.

IT has been said all globules of Farina burst when wetted, and discharge ELASTIC ATOMS: some burst readily; others do not: but whenever they do burst, what they discharge is this embryo Plant, encompassed with a waxy matter, which, not mixing with the water, appears granulated. That is all.

IT seems, from the experiments I have hitherto made, that those Farina which have rough surfaces, and are large, burst upon the head of the Style; as the Mallow kinds; and only the embryo Plant, covered with is waxy Juice, enters the Seed-Vessel: on the contrary, that those Farinae which are small, smooth, and of a fit shape to make their way entire into the Seed, are received into the Pistil without bursting: this is the case universally with the Farina of the Radish, which therefore does not burst so readily in water. However, as moisture is in the end to cause its opening, what is to be transacted naturally within the Seed, may be done on the plate of glass. The Farina must be perfectly ripe for this purpose; a great deal of it must be laid upon the glass, and the drop of water often renewed. By this means we shall see one or other of the Globules burst: the opening always is at the line in the center, and usually towards one

end ; and there comes out a mass of soft but granulated matter, which might be supposed a cluster of elastic atoms. Fig. 24. To know what it really is, another course is necessary. The drop of water must be suffered to dry away, and a drop of oil must be put in its place. Observing this from time to time, we see the granules, which seemed atoms, dissolve into a smooth uniform substance, which, as it is thus rendered thin, becomes transparent ; and we discover in it that annular rudiment of a new Plant very distinctly, which we had seen obscurely in the entire globules. The lump thus melted is represented at 25, with the embryo in the middle of it, and at 26 the embryo alone.

THERE is no other way of examining the Farina of Plants. Reason dictated this ; and I have been so happy to find it succeed perfectly. I saw their error who fancied the waxy matter of the Mallow Farina to be distinct hard bodies, and who extended one observation as a law to universal Nature.

I FOUND, what all will find who try, that few Farina burst in water. It was plain, that the solid matter in the Farina could be no other than one single piece of the parent Plant ; and what was there beside, could be only the Juices of the Vascular Series, since no other part of the Plant beside the Flesh and this had any communication with the Farina, or, indeed, with the body of the Filament. Many observations had shewn me, the Juice of the Vascular Series was waxy ; indeed I am persuaded, all the wax which bees collect has this source, and no other : whatever therefore would dissolve wax, would have the same effect upon this Juice in its clustered state about the embryo, and whatever dissolved this, would shew that embryo : on these plain principles I used oil, which is the simplest of all the dissolvents of wax, and the least opposite to the vegetable nature : the effect was as expected ; and this way I obtained what others may at any time obtain by the same means, a plain and distinct sight of the embryo Plant.

THUS we see what the original embryo of the Plant is. We find it is a naked circular piece of Flesh of the parent Plant, defended from decay by being covered with a substance indissoluble in water.

THESE Embryos, millions of which are contained in every Anthera, are to be received into the Seeds ; and it will be necessary to examine now, by what passage they are to get at this ; and what is the condition of that Seed before they reach it.

C H A P. XXX.

Of the CONVEYANCE of the EMBRYO into the SEED.

NATURE provides, for the reception of the Embryo, thus form'd in the Farina, a peculiar case, the Seed, which receives it naked, and gives the first means of a limited growth. In the center of the Radish Flower there rises a slender, long, irregular cylindric body, crowned with a small rough head. The cylindric body is the young Seed-Vessel, and the rough head is the Stigma, which is rough for detaining the globules of Farina, and moist to make the passage of the Globule easier into the Seed-Vessel; that being its office. See Fig. 27. It is formed of tubes with open mouths, capable to receive the globule of Farina; and these, after a short straight course, all open into the hollow of the Seed-Vessel.

IF we cut open the Seed-Vessel in this tender state, and before the Seeds have received the embryo Plant, we shall find plain proof that they have this and no other use. For this purpose we are to chuse a flower not yet open. In this we shall find the Filaments very short, the Antheræ long and entire, and the rudiment of the Seed-Vessel tender and whitish; if the Seeds have any young Plant in them now, it is their own, for no grain of the Farina is yet shed; indeed they are scarce formed.

WE find on cutting the young Seed-Vessel transversely, that it contains a double row of rudiments of Seeds, with a column in the middle; and a quantity of spongy matter among them. This is represented at Fig. 28. On cutting it lengthwise, we see that the column in the middle of the Seed-Vessel is continued to the very summit; and that the rough head or Stigma, is only a continuation of this column without the investing Membranes of the Pod. See 29. The Seeds arranged on two sides of this column, adhere to it in the very manner that the globules of Farina do to the inner surface of the Anthera, that is, they rise from it: they are originally blisters in the surface of the Receptacle, and they retain to the last their opening into it. This is represented at 30.

THESE Seeds in so young a Pod as we are now examining, are mere transparent Blebs or Shells, opening by an oblong mouth into the hollow of the column. In a Flower a little more advanced, we see this Shell filled with a thick white fluid, and in this condition we always find it, with this simple and uniform appearance in the young Pods of those Flowers whose Anthera are not yet burst. Such a Seed is represented at 31, filled with

with its thick Juice, but with nothing else in it, and with its original aperture where it adhered to, or grew from the column.

If, after repeating this observation on the Seeds of many Flowers in the same state, we afterwards examine the young Pod in a Flower whose Antheræ have burst, we see a very manifest difference. We find the Seeds of the same form, and filled with the same thick Juice; but we also see in each a small solid and not transparent particle. See Fig. 32. This solid particle is of the same form and size with those in the globules of the Farina. Those globules have been discharged from the Anthera: there is a plain way, and in this Plant a very easy one, for them to these Seeds; and therefore we can have no reason to doubt this is the very particle that was in the Farina. The object is very minute, yet an accustomed hand may draw it out of the soft tender Seed, and obtain conviction from the Microscope, that it is the very annular embryo of the Farina figured at 26, not yet in the least altered. It is a naked ring of the Flesh of the parent Plant. By degrees this naked embryo gets its several coverings, the thick Juice of the Seed is received into two Seed-Leaves; and the present growth ceases. A Seed in this State cut thro' transversely, and a thin slice of it powerfully magnified represents the embryo Plant still retaining its annular form, and only altered by a protuberance from one part, which is the first push toward the growth of the Plant. This is represented at Fig. 33, and the Embryo separate at 34. This is the condition of the perfect Seed of the Radish. This Embryo is the Corculum or Heart of the Seed; and is ready to grow, on being planted.

THAT this Corculum of the Seed is really the Embryo originally produced in the Anthera, is evident from those observations; and the fact never fails to be ascertained by many casual incidents in the course of the enquiry. The Globules of Farina are, in great part, scattered in the air, but many of them fall upon the Stigma, whose moist open Vessels convey them, by a plain short course, into the hollow of the column, along which, from top to bottom, are two rows of openings leading into the several Seeds. In opening the young Seed-Vessel lengthwise thro' the center of the column, and the head of the Stigma, when the Antheræ have newly burst, we see not only that the Tubes of the Stigma all open into the hollow of the Column; but we see in these Tubes, as well as upon the surface of the Stigma, many globules of the Farina, and multitudes of others which have passed those Tubes, sticking to the inside of the Column. Such of the Globules as fall upon those places where there are openings into the Seeds, naturally enter into them; and there, while the Juices yet

yet come into the Seed-Vessel, take their first growth; which forms the protuberance seen in the perfect Seeds, and gives the Embryo all its coats, and Seed-Leaves. This done, the Juices no more flow into the Seed-Vessel; every thing hardens; the Seeds in time become loose, dropping off from the Column; and the aperture by which they communicated with the inside of the Column, contracts in the manner of a scar; but still there is a little opening left; which glasses will discover; and out of which the Plant afterwards shoots.

THUS is the Seed of the Radish formed, including a minute embryo of a new Plant; whose progress in growth we are next to trace. This will be an easy task, the object being large enough for the naked eye to examine, and even the whole structure plain to very small powers of magnifying.

C H A P. XXXI.

Of the GROWTH of the PLANT from the SEED.

THE ripe and perfect Seed of a Radish is composed of four parts.

1. A brown hard Shell or Rind, *a*. 2. A yellowish pulpy substance, formed into two doubled flat plates, appearing four, *b*. 3. The Heart of the Seed, which is the Embryo conveyed thither from the Farina, *c*. And 4. A fine thin white Membrane, *d*, placed between the Embryo and the Shell, in that part where the Seed originally adhered to the Column while it was in the Pod; this is now continued as a covering to the Embryo to the place where it joins the two inner plates. The Seed cut asunder transversely, is represented at Fig. 35; the section being made near the place where it grew to the Column; in this we see distinctly all the parts. *a* is the brown Rind; *b* the outer folds of Plates; *c* the inner folds, smaller, and gathered closer round the Embryo; *d* is the Embryo, and *e* the fine white Membrane torn from the place where it adhered to the outer Shell.

THERE is a little hollow about the Embryo, and its smallest end stands toward the surface of the Seed, covered with this Membrane. With careful management we may separate this Embryo from the Seed: we then find it a small oblong body, pointed at one end, and the other spreading into those two plates which run from it on each side, and terminating between them by a small curled head. The entire Embryo taken out of the Shell is represented at 36, *a*; and opened at 36, *b*, where we find plainly

plainly that it is no other than the particle of the original Flesh, 34, somewhat larger, and with a beginning of growth; the part 34, *a*, is the same with 36, *a*; and 34, *b*, the same with 36, *b*. And the whole being split, and viewed in a thin slice by the Microscope, still shews itself to be the same original elliptic ring of Flesh which was produced in the globule of Farina, 37. All the difference here is, that this Embryo is clothed with several Coats, not naked, as it was produced there: and that at the end, *b*, which is to give rise to the ascending Stalk, it has shot out two broad plates, and a small convoluted head between them. These two plates are to be the Seed-Leaves of the future Plant, the convoluted head is the first rudiment of a Stalk, and the end, *a*, is to extend itself into a Root.

THIS Embryo is what has been called the *Plantula Seminalis*; and people have fancied they saw in it the entire future Plant; not knowing that the Flowers, and other parts, were to be absolutely produced in the succeeding Plant by the plain course of growth; but conceiving they were all here, and only to be unfolded. If we proceed to cut the Embryo taken from a perfect Seed transversely, we may with powerful glasses see in it every one of the seven constituent substances of the succeeding Plant. They are far from distinct: an eye not before informed what were the constituent parts of a Plant, would have little chance to discover them; but being known in the Vegetable Philosophy, they will be all found in their places here.

THE entire Seed of the Radish is of a figure approaching to oval, but irregular; the Skin is brown, and there is a black scar at the place where it originally grew to the column in the Pod. Against this part of the Seed is placed the part *a* of the Embryo, 34 and 36; and at the opposite end the part *b*, where the Embryo spreads into the two Plates and intermediate Crown.

THE Seed being put into the ground, receives moisture, and its inner substance swells. The original Juices in the Embryo, *a b*, 36, are diluted by the fluid received from the earth, and the continual changes of the temperature of the air, in respect of heat, put all in motion; for every thing swells with heat and shrinks with cold; and there is no minute in the day wherein there is not some small change in the degree of heat about us. Little changes affect little bodies; and consequently these affect the moistened Embryo in the Seed. The Juices being made thin enough to flow, are forced along the Vessels by this alternate contraction and dilatation of the body itself; and new nourishment being supplied, the Vessels become extended, and increase.

ALL this is tranſacted in the body of the Seed, which is yet entire. But when the brown Coat is capable of no more diſtention, it burſts uſually at the bottom, that is, the part oppoſite the ſcar; and gives way to the ſwelling Embryo to ſpread. A Seed perfect, and fit for ſowing, is figured at 38: and at 39, one burſt, and letting out the embryo Plant.

THE brown Skin, which is now of no more uſe, may be eaſily taken off; and we then ſee the naked embryo, 40, conſiſting of a conic white part, and a rounded, but flattened body, compoſed of two doubled Plates, between which, tho' on one ſide, runs the conic part.

THIS little Cone is the original annular Embryo of the Farina, now conſiderably lengthened, but no other way altered; and covered with its Coats. The broad flakes are the matter of the body of the Seed, now formed into the rudiments of ſeminal Leaves; and tho' they had appeared to be four, we find in this advanced ſtate that they are but two. They are not ſeparate at the edge oppoſite to the little cone, but only folded for the convenience of being contained in that ſhell.

WE now find, that theſe two parts, the Cone, and the pair of Leaves, make up the whole body of the Seed; and this confirms what was before ſaid of their origin; that the original of the Embryo of the Farina plainly begins its growth in the growing Seed; that the Juices ſent thither ſerve only for its nourishment, and that thoſe two folded Plates, and its Crown between them, are its firſt growth; which ſtops only becauſe no more Juices are ſent thither. In ſome ſpecies the Embryo grows more, in ſome leſs, in the Seed; but that is all the difference.

AFTER the brown Shell of the Seed is fallen off, and the young Plant is looſe, the Progreſs in growth is very quick. The Cone, 40, a, lengthens, and becomes a Root; and the two folded Plates enlarge, and ſeparate at their edges, and begin to ſpread aſunder. We perceive very diſtinctly, that the back of each is entire, and we ſee one riſing above the other, as at 41. Thus that part of the Embryo which has extended itſelf downwards for a Root, acquires its proper form, and is committed naked to the earth; from which its ſpongy ſubſtance attracts nourishment: but the convoluted head, which is the firſt rudiment of the Stalk, is ſtill cloſe covered by theſe two Plates, and is a mere dot, making no advance toward extension.

ALL this is tranſacted within the earth therefore the parts have not their proper colour; theſe two folded Plates, which are preſently to become what we call ſeminal Leaves, are yet yellow. This may be called the FOURTH ſtate of the Plant.

HITHERTO

HITHERTO all the parts have kept their places, only the Cone has lengthened: but as they will be moved a little hereafter, it is now we are to ascertain their original. We see the particle, 34, which I have called the Annular Embryo of the Farina, is the original Rudiment of the new Plant: it has in the Seed sent off its two folded Plates, and has begun a little to extend the opposite way in length. It will be important to know at what point in the succeeding Plant the growth began, which has extended it so far each way: and this must be ascertained now. It is the part marked *b* in Fig. 36; *c* in Fig. 40; *d* in 41. This was the center of the original annular Embryo 34, the part *d*; and this has in the succeeding growth to the fourth state, Fig. 41, extended itself in length in the Root downwards, to several times its original bigness; and has made a very minute advance upwards, in the convoluted Head or Bud; which is hitherto almost imperceptible.

AFTER a little time the young Plant advances from the irregular form 41, to the proper appearance of a Seedling. As we are to count every article of growth from the place of the original annular Embryo, it will be proper to mark that every where with some one appropriated Figure as *. This is added to the *d* 41; and by this mark we shall know the same spot of origination in all the states of the Plant. The first advance the Embryo 41 makes toward a Seedling, is by the expanding, separating, and, in some degree, raising the two folded Plates, which we are now to call Seminal Leaves. This is naturally transacted just at the surface of the ground, or, as we may say, between earth and air. The Plates now shew their true form, being broad, short, and dented at the end; and they now begin to shew also their green colour. See Fig. 42. The point of growth *, now swells a little, and just upon its summit, between the bases of the two Seed-Leaves, appears the Bud.

THE growth from this state is quicker than before, and the Plant increases very considerably; the perfect Seedling is represented at 43: and from the former course it will be easily understood how it has acquired this form. The part *, which in 41 was under the earth, and in the state 42 had reached the surface, is now raised considerably above it. If the line *a* be made the surface of the ground, this will be understood perfectly. We are not to suppose the Plant has yet any Stalk. The seat of growth is at *; and tho' a part of the Plant is raised above the ground, yet we know this is the point of distinction between Root and Stalk: from this point * downward, is Root; and from this point upwards, is Stalk; no matter where the surface of the earth comes.

THE original of a Stalk is the Bud *c*, which has yet made no advance whatsoever toward rising. Therefore in the Plant represented at 43, the part from * to *b* is Root; that portion between *a* and *b*, is the Root under the earth; and the part from *a* to *, is the Root above ground. The Bud, *c*, stands close upon the head of the Root; and the Seed-Leaves, *d d*, having risen on a kind of Footstalks, the Bud, *c*, is defended very finely by the hollow bases of those Footstalks where they lap over one another. The rudiments of these Footstalks were always to be seen at their base, tho' very small, and their extension in length is from the mere ascent of the Sap. These Seed-Leaves are now at their perfection and the next force of Nature is directed to the Bud.

THE advantages a Plant receives from the air are very considerable, and they are obtained by means of the Leaves; which discharge a great quantity of moisture during the day, and imbibe a great deal during the night: the healthy state of a Plant always depends upon this, and in most circumstances its life, as we see by taking off the Leaves of Trees and Herbs, during the season of their growth. The first Leaves of the Radish are these, and it is so in most other Plants. Till they obtain their state of perfection, the Bud makes no advance toward rising. The Juices which have been received from the earth, have swelled the Vessels, expanded and enlarged the Seminal Leaves, and sent down the Root to some considerable length; but more was needful to increase the Bud, a communication between the Vessels of the Plant, and the free air; and nourishment received thence: these Leaves are now in a condition to give it; for they are perfect: therefore the Bud now begins to disclose itself. To know how these two Seminal Leaves perform this important service, we must examine their structure.

C H A P. XXXII.

Of the STRUCTURE of the SEMINAL LEAVES.

WE see that what is called a Seed, independant of the original Embryo, is a shell, and nothing more; therefore it is in the progressive growth of that Embryo, we are to seek the whole fabrick of the succeeding Plant. It was delivered naked into the Hull of the Seed; there it got its coverings, and shot out from the upper end two flat and folded Plates. Their use we see now; for in the second growth they are to become the Seed-Leaves.

This

This growth of the Seed when put into the ground, may justly be called the second; for the first was absolutely taken while the Seed was nourished from the Plant. We have traced the growth of these folded Plates into absolute Seed-Leaves, raised upon Foot-Stalks, and with their just green colour. Fig. 43. In this state of the Plant, from the point *, to the extremity of the Root in the earth, is one simple uniform body; and this is, properly speaking, all of it the Root of the Radish. A transverse section of this shews all the seven constituent parts: we distinguish easily a red outer Bark, a whitish inner Rind, a large white Blea, a pale Vascular Series, a green Flesh, six Conic Clusters of Vessels, of a deep green, and a white Pith. The Blea bears a great proportion, and the Pith is but in moderate quantity. See Fig. 44.

WE see the Root is perfectly formed: indeed, in the Course of Nature, it could not be otherwise, for all this part, from * to the extremity downwards. 43, is no more than the original annular Embryo, 34; which has extended itself in length, and in some degree also in thickness; but without any violence to its own construction. We see the progress of this growth superficially in the enlargement of the little Cone or embryo Root; 35, 36, 40, 41, 42, 43. But to understand it perfectly, the Cone or annular Embryo must be split lengthwise down the center, in all those states; and viewed with some assistance of the Microscope. In this method we find the Cone *a b*, 36, a very small advance from 24. The Cone or growing Root of the Embryo 36, is represented thus split and magnified at Fig. 45. And we thus see the beginning of the increase of the Coats, that of the Blea growing fastest: there is in this a small Pith. If we cut the same Cone transversely, we see six dots, which, indeed, are visible, with sufficient magnifiers, originally in the Embryo itself, before its growth begins; and are the sections of the six conic Clusters of Vessels.

If we again dissect the Root at the growth 41, we see no other change than a gradual increase. This Root, which is now the essential part of the Plant, has grown in a degree much greater than the Leaves, and the Bud scarce at all: we still see the original Embryo increased in length, and covered with more distinguishable Coats, but nothing else: counting from the point * to the extremity, the whole is still an annular body, vastly lengthened, for the Coats all return upon themselves at the lower end of the Root; and the original substance or Flesh of the Root, returns also upon itself, at the upper extremity or point *, tho' it sends up a portion from its surface to the yet dormant Bud. See Fig. 46.

NEXT if we split lengthwise the Plant in the state 42, cutting thro' the two Leaves and Bud, we see the same form and condition of the whole, only more grown: the Root is longer, and its Blea and Pith are in much larger quantity; but the Bud is not yet at all advanced. See a magnified section of this at Fig. 47. The original ring of Flesh, which was the Embryo in the Farina, is extended in length, and covered, but nothing more: and we still see the several parts all rounding the end of the Root, and the Flesh, making an arch at the head of the Root, the point * from whence the Bud rises. The Bud is little altered; but we see the Seed-Leaves just in that part, begin to rise on Footstalks.

LAST of all in the examination of this state of the Plant, it will be proper to cut strait down, in the same manner, the entire and perfectly grown Seedling. 43. This will shew us the growth and use of the two first Leaves; and the distinction and connections of the several parts of the Plant. A section of this kind is represented at Fig. 48. If we begin the examination at the point *, we there find the original termination of the annular Embryo still preserved entire; and as the whole Plant above the ground, is to rise from this point, we see a provision for such a work: the Flesh extends to three or four times its usual thickness in this part; and the arch is formed entire, tho' less vaulted than usual in the lower side of it. From the upper part and outer surface of this swoln portion of the Flesh, arise all that is conspicuous in the Plant. From the outer surface of the Flesh of the Root continued in this swelling, there is sent up on each side a portion of its substance, which runs strait up the center of the Footstalk of each Seed-Leaf, 48, a. Within this are the Conic Clusters, tho' not easily seen in the longitudinal section, 48, b: and over these two substances run up regularly the Blea, and the two Rinds.

WE may judge of the importance of the Seminal Leaves of Plants by this construction. The permanent Radical Leaves of the Hellebore consist only of three substances, the inner Rind, and Blea with the Conic Clusters. But these, short as their duration is to be, carry up also a part of the Flesh of the Plant. We have seen that this is sent up from the surface of the Flesh of the Root; and the Vessels of the Conic Clusters are formed within this, in each of the Footstalks; but the Blea and the two Rinds, *cde*, are all simply continued from those parts in the Root. A piece of a Footstalk more enlarged, is shewn at Fig. 49. From the upper surface of the central part of the swoln Flesh at the head of the Root, rises the Bud for the future Plant, *f*.

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THUS the Flesh makes its regular course in its lengthened annular form along the Root, and only from its surface gives these parts which are to appear above the ground: the Flesh of the Bud upwards, and that portion of Flesh which is allotted to the Seminal Leaves sideways.

WE are now to examine the proportions of the several parts in the Footstalks of the Seed-Leaves by transverse sections. The flattened, hollowed form of the Footstalk makes a transverse section of it appear somewhat in the form of a Crescent. The outer Rind, which was red in the Root, continues its colour also in this part, and even the Vessels of the Blea have a red liquor. This distinguishes excellently the Vessels of that part from the Cells which they form, and which some have taken for Vessels; the fluid in those cells being colourless, while this is red.

WE have had occasion to remark a swelling of the head of the Root, at the point *; this is owing to the swoln state of the Flesh in that part, which forces out all the others; it is here a portion from the surface of the Flesh is sent up into the Footstalks of the Seed-Leaves, and this at its very origination in quality of the Flesh of the Footstalk, divides into three regular portions: each of these forms an inverted arch upon the surface of the swelled part, and rises hollow into the Footstalk.

THUS are formed three tubes, as it were, of the Flesh of the Plant, connected intimately with that of the Root, but whose hollows do not open into it. These fleshy bodies divide themselves to a distance, one running up the center, and the other two near the two horns of the Crescent: they are not surrounded with a Vascular Series as the Flesh of the Root, and Flowering Stalks of Plants, nor have they any Pith within; but each of these tubes gives origin to two Conic Clusters of Vessels, which run up within it to the Leaf: each of the side ones again dividing toward the Leaf so as to form four. A section cut transversely, and with due care, from the surface of the swelling at the head of the thick part of the Flesh, shews this distinctly: such a section is represented at Figure 50. The disposition of the three tubes of Flesh, and of the two Conic Clusters of Vessels in each tube, are represented at 51—a, as they appear in a very thin section of the Footstalk of a Seed-Leaf, near the base; and in another section taken near the Leaf, at 51—b.

THUS the law of Nature, in the origination of the Conic Clusters, is invariable. As there are six in a Fibre, and twelve in the body of a Root in Hellebore; so there are six only in the body of the young Root of Radish, and ten in each of the Footstalks of Seed-Leaves, that rise from it; and in neither case do the greater number above take their origin from

the smaller number below, but are produced anew in the parts where they are found. The course of these tubes of Flesh is easily traced upwards, in the Footstalk, to the place where it expands into a Leaf.

As the Seed-Leaf is an absolute expansion of the Footstalk, and nothing more; there can be no fixed point assigned, where the Stalk ends, and where the Leaf begins: but if we observe the part *a*, in Fig. 52, as the beginning of the Leaf, we shall see readily what course the three tubes of Flesh, with their clusters of Vessels, take. The Fig. 52, represents a perfect Seed-Leaf, with its Footstalk a little enlarged. In this we see, even in the Footstalk, the three fleshy bodies: the largest, *b*, runs up the middle, and the two others, *c c*, uniting again toward the base of the Leaf, as they did at their rise, run up the two edges. When the Stalk spreads into a Leaf, their course is not altered, the fleshy body, *b*, keeps its rout uninterrupted up the middle of the Leaf, and becomes what we call the Middle Rib; and the two others keep also their course along the two sides of the Leaf. There are two or three subordinate Ribs also, which rise from the principal or middle Rib in the body of the Leaf; but these are altogether distinct: they are sent off from the principal fleshy Tubes; whereas the two distinct side Ribs have shared its origination, and rose with it.

If we trace first the two side Fibres of the Leaf, we find them in their passage divested wholly of the coat of Flesh which covered them in the Footstalk: this grows thinner as it approaches the part *a*, Fig. 51; and at a little space higher in the Leaf ceases entirely. We have seen that the whole of this body was a Tube of Flesh with two of the Conic Clusters of Vessels; as the tube of Flesh diminishes to nothing on entering the Leaf, we see in the upper part of the Leaf the Conic Clusters freed from any covering. These Clusters are formed partly of green Vessels, and partly of a white spongy matter; even these constituent parts of the Conic Clusters separate in the body of the Leaf; the two Clusters of green Vessels run up distinct at a small distance from one another, and the white spongy matter is placed in a large body between them, and in some degree also surrounds them. The middle Rib being more compact, does not separate so much; but usually its two Clusters may be seen very distinctly, and the better as their Juice is red. The course of these Vessels is represented at Fig. 52.

THE Seed-Leaf is composed of all the substances we have seen in its Footstalk, except the Flesh: and they are thus disposed. The outer Bark of the Footstalk, which is a continuation of that of the Root, forms what

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we call the upper and under Membranes of the Leaf: these are really one. The Leaf is a spongy body, covered by the extended and dilated Membrane of the Footstalk; which does not separate at the extremity, but, on the contrary, is more firm and compact there than elsewhere, from the innumerable inosculations of its Vessels: it forms in that part a kind of flat cord surrounding the Leaf.

If we take off this Membrane, which may be done by due maceration, we find the Vessels disposed in the usual way, in that part of it which covered the Footstalk, and the Membrane entire and unperforated between them: but in that part which covers the body of the Leaf, these Vessels are separated to a greater distance; and in the plain Membrane between them, there are innumerable oval apertures. This is shewn in Fig. 53, which represents the outer Bark of the Footstalk and Seed-Leaf entire: *a* shews the course of the Vessels in the Footstalk, with the Membrane entire between them; and *b*, the same Vessels in the coat of the body of the Leaf, where they are more separate, and have those oval apertures between them. We therefore see, that whatsoever is the office of the Leaf, the Footstalk does not perform any part of it in common, but serves only to raise the effective part of the body of the Leaf to a proper height in the free air.

UNDER this outer Bark is spread the inner Rind. They are distinguished by their colour and consistence: the outer Rind being very thin, and perfectly pellucid; the inner Rind somewhat thicker, a little cloudy, and green. This is, in the same manner as the other, continued from the Root thro' the Stalk to the Leaf, where it expands, and consequently the Vessels become more separated: the Membrane between these Vessels is entire on the Footstalk, as the other; but in that part which covers the body of the Leaf, it is pierced with innumerable holes: these are much smaller than the mouths of the outer Bark, but they many times exceed them in number; and they are not oval, as those, but round. This second Rind of the Leaf is represented at Fig. 54.

THESE make the coverings of the Leaf; but its thick substance is form'd by the Blea: this runs between these double coats, and is a mass of sponge.

WE know the structure of the Blea; and in the Leaf this is the same as in the Stalk, only for the different disposition. The Blea of all Plants is a mass of cells, formed of Membranes, and supported and separated by Vessels. In the common course of the Blea in the Stalks, and other parts of the Plant, the cells of it run strait between the coats; but in the body
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of the Leaf they turn their mouths every where, instead of their sides, to the surface, and consequently a perpendicular view of the surface of the Leaf, on either side, shews us innumerable openings, which the two Rinds but imperfectly hide. In the present view, these Rinds being removed, the mouths of the cells are more distinct, and the Vessels are as visible at their corners and division.

Thus the body of the Leaf is a mass of Blea, whose Vessels and Cells do not pursue their plain course from the base to the summit of the Leaf, but open each way to the surface. See Fig. 55. It is observable also, that the Vessels of the Blea are larger here than in the rest of the Plant. In this Blea, as in a bed, are lodged the Conic Clusters, running from the base of the Leaf toward the summit, in a plain course, surrounded by their peculiar spongy matter: this continues white; but the Juices of the Vessels themselves are either richly green or red.

Two of these Conic clusters of Vessels, we have seen, make the body of each of the principal Ribs: they run pure up these, and separate from the spongy matter which lies about them. Tho' they are large at the base, they diminish toward the other extremity; and being buried in this large quantity of Blea in the body of the Leaf, are lost to the view; but when we have separated the two coats, the Blea will not obstruct our sight of them by the Microscope. When we lay before it an entire Seed-Leaf, stripped of its coats, we see these Vessels run nearly, but not absolutely, to the extremity of the Leaf. In their course they send off many side Fibres, which are so many portions of their own substance; each consisting of a number of Vessels; and when arrived at the extreme end of their course forward, they turn their points, and keep on in a new arched bend, formed by the figure of the outline of the Leaf, till they inosculate one with another; the middle with the side Ribs, and these again with that. The side Fibres pursue a like course, and do not come to an absolute termination any where, but all inosculate one with another; often in considerable large branches, sometimes by such as are too small for the view even of the Microscope. Fig. 55 represents the course of the Vessels in the Blea; 56 the Vessels separate.

FROM this construction of the Seed-Leaves of Plants, it is not difficult to learn their use. We see their several Coats and Blea are so many continued substances, with the same parts of the Root; and that the Flesh, and clusters of Vessels, tho' they be not continued from the parts of the same nature in the Root, yet are derived from them, and communicate with them at the point *, where the young Stalk is to rise. This is the
important

important part of the Plant; and this is fed from two sources; these Leaves as well as the Root.

THE course of the Vegetation of the Radish, to the present period of its growth, seems to be this. The Vessels of the Root having received their due portion of nourishment, principally at the spongy ends of the Fibres, the whole substance of the Embryo has been expanded, and increased, so far as to be terminated by the two large Seminal Leaves. Thus much the Juices of the Root have been able to perform: there remains the Bud to be fed for rising to a perfect Plant; and there is now an expanse of surface for receiving nourishment in a due proportion for that service; and an apparatus of Vessels for the preparation and distribution of it. A certain quantity of Juices is received from the earth; and in the hours of early morning the whole Plant is full of it. As the day rises, the heat evaporates a great deal of this; and tho' more is raised, yet is not the supply, perhaps, suited to the waste. At evening, when the heat decreases, and the air is full of moisture, these spongy surfaces of the Leaves imbibe that moisture in abundance, which fills all the cells, and gives sufficient matter, out of which the Vessels may elaborate the proper Juices of the Plant. Whether the nourishment rises from the Root, or is taken in at the Leaves, it must, in its course, pass the point *, where is placed the rudiment of the Stalk; and the swelling there seems appropriated to detain it.

WE see the Membranes of the Leaves are perforated, and their inner substance is a sponge, whose open mouths answer to those perforations. Therefore the moisture which falls upon these Leaves, is easily received into their substance. It passes the outer Bark by means of the oval apertures; these let it into the space between that and the inner Rind. The innumerable round apertures in that coat let it thro' again; and just under these are placed the open mouths of the cells of the Blea, into these the pure moisture enters. These cells are continued, without any valve, or other interruption, thro' the Blea of the whole; so that the fluid thus received into them at the Leaves, mixes at once with that of the whole body of the Plant. In the same manner moisture is taken in at the Roots, whose spongy heads or extremities are formed of open cells of Blea, covered only by the two peried Rinds.

THUS it appears that moisture is received into the Plant; and fills those cells of the Blea, which make up the greatest part of the Vegetable substance. About the sides of these cells are placed Vessels, with openings into them, which have glandular mouths: and thus a portion of this wa-

tery nourishment is secreted, and becomes in part the Juice of those Vessels. At the same time the Vessels of the outer and the inner Rind having received, and separated part of their Juices, deliver these also to the Vessels of the Blea; so that in those Vessels is contained a fluid variously elaborated, and regularly mixed.

THESE Vessels of the Blea send branches without number to those of the Flesh of the Plant; and from them, in the course upwards, a part of it is given to the Conic Clusters; and in a contrary manner a part of that delivered from the Blea of the Leaves to the Conic Clusters, is delivered again in its course downward to the Flesh near their bases.

In the middle part of the young Plant is placed the swelling 49, *a*, from whose surface many of the Vessels of the Leaves arise, and with whose substance they all communicate. From the center of this swelling rises the Bud for the succeeding Stalk. It is the middle point, to which nourishment from both extremes is directed, and which at all hours of the day and night receives it from one or the other.

THUS the watery fluid in the cells of the Blea is continually rising and falling, according to the degree of heat; and that rich Juice separated from it in the Vessels of the same part, feeds the essential portions of the Plant.

WE have hitherto examined the preparatory parts; we are now to trace the Bud up to a perfect Plant. It has lain dormant hitherto; but the double supply of nourishment it receives, will now set it to growing.

C H A P. XXXIII.

Of the FORMATION and GROWTH of the STALK.

WE have seen from the earliest state of the Embryo in the Seed, to the full growth of the Seedling Plant, a small Bud placed at the point *, or head of the Root: and while the other parts have taken so much growth, this has had but little increase. In the Embryo, Fig. 34, the point *b* shews the origin of it; and to the Fig. 94, it has made very small advances. At first it appeared a small curled Bud; as the Plant advanced it increased a little; and in the state 42, where the Seed-Leaves want little more than their Footstalks, it appears somewhat less compact in its texture: when the Seed-Leaves have their Footstalks, and perform their office, it grows quickly: we see it in one day increase to three times the former bigness and open a little at the top. One day more enlarges it, and expands

it so much farther, that we may distinguish it as divided into parts; and from this time new Leaves, peculiar to the Plant, are formed daily; and it assumes its proper form.

To understand the progress, we must begin with the dissection of the Bud in the perfect Seedling; sooner than that it discloses nothing distinctly; but at that period we begin to see its construction, which becomes more evident from time to time afterwards. We see, in Fig. 49, the manner wherein the Bud rises from the head of the Root; and if we cut a thin slice lengthwise from this section, and apply more power of magnifying, it appears as at Figure 57. The Flesh of the Root returns in an irregular arch at *a*; at *c d* rise the two portions of it sideways, which run into the Footstalks of the Leaves; and at *b*, from the very center, ascends the little Bud. It is a hollow cone, formed of the Flesh of the Plant, arising from the mass of Flesh *e*, and is already filled with a fair Pith in large proportion. This Pith has plainly risen from the upper surface of the mass of Flesh within the outline of the Cone; and its early appearance in this place confirms the opinion, that wherever the Flesh of a Plant forms a cavity, a Pith is produced to fill it.

A SECTION of the Bud, altogether separated from the rest of the Plant, is shewn at Fig. 58. To illustrate this construction. In this Figure, a represents the Pith, over which lies the cone of Flesh *b*. On the surface of this we see a Line, *c*, scarce distinguishable, which is the section of the Vascular Series: above this comes a large Blea, *d*; and on the outside of this appear the two Rinds, *f g*. Thus is there lodged upon the crown of the Root, the Bud of a future Plant, which has yet only a short rudiment of a Stalk, *h*, to support it; and is cloathed, as it were, in so many shells by its several outer Membranes. This we are to trace in its growth, into an entire Plant: but we are first to consider the origin of those Leaves which rise from the Root next after the Seed-Leaves themselves, and which supply their office in a larger way when they are faded. These are not produced together with the Bud. We may be sure of this by the preceding observation; for we see the Bud when the young Leaves are separated from it, absolutely naked. What is figured at 58 is the rudiment of a Stalk, and nothing more. Nor are even the two Leaves which defend it formed of any part of its substance. There are eight or ten following these; and if they were in small upon the Bud itself, we should, by the power of Microscopes, distinguish them: but it is not so. They are produced afterwards from the surface of that very short rudiment of a Stalk

which bears the Bud ; and by tracing their first formation and growth, we shall be led to the system of increase in the whole Plant.

IN the absolute state of the Buding there rise two Leaves from the surface of that short rudiment of a Stalk ; the one a little higher on it than the other. These are defences of the Bud ; and when in the state of growth, they spread out from it, as in the Figures 59, 60, 61. Two others rise within their bases, or between them and the Bud in the same manner. Thus are gradually produced, and thus are enlarged, all the Radical Leaves ; a considerable number of which are produced before the first rising of the Bud toward a Stalk.

WE are to examine by what means they are formed, and of what parts they are composed ; and this will be best traced by the help of Glasses, in this very minute state : tho' it may be very happily illustrated afterwards, by what the naked eye sees of them at their full growth.

AT the point *, which is the part where the Root terminates and the Bud rises, the two Rinds and the Blea go off to the Seed-Leaves ; yet are not the Bud or the rudiment of a Stalk on which it stands, destitute of the same substances ; for these are all formed regularly and easily wherever there is the least Flesh of the Plant.

THE origin of the Radical Leaves is like that of the Seed-Leaves, from a part of the Coats and other substances rising obliquely outwards from the rudiment of a Stalk, at the same time that a portion of the same parts covers also the surface of that rudiment. This will be understood easily by the origination and construction of one of these Radical Leaves, examined by the Microscope ; for, indeed, it is one and the same substance of each coat which covers the rudiment of the Stalk, and the Radical Leaf : that is, the whole Leaf is formed by the growth of parts from that rudiment, and its Membranes are only expansions of the coats of that part.

THE Radical Leaf, in this Plant, consists of two Membranes, a Blea, and three original conic clusters of Vessels, which soon divide into more, and which rise covered with a thin coat of the Flesh of the Plant. Their origination is this.

As soon as the Seed-Leaves are expanded to the air, the vast quantity of moisture they receive from thence occasions the Root to grow, and fills the rudiment of the Stalk with nourishment. The first effort of this is on the Flesh of that rudiment ; and from one side of it, near the head of the Root, there rises a little process from the surface of the Flesh, which points obliquely upwards : immediately a smaller Blister is formed on each side of the first ; and these pushing in the same direction, raise the Blea, and the

two



The Formation & Growth of Plants.



two Rinds, above them. This is the origin of a Radical Leaf, differing scarce at all from that of a Radical Fibre, as has been shewn in the Fibres of the Hellebore. Within these portions of the Flesh are produced conic clusters of Vessels, which after a time are divested of that covering, and run free, just as in the Seed-Leaves, to the extrem parts of the Leaf.

To know the true origination of these, we must go back to the young Plant, and its Conic Clusters. A section of this below the point *, shewed these to be six: as this part, which is the Root, continues to grow, it increases vastly in thickness; and each of these clusters separates, first into two; in which state they are twelve: thus we find them in a half-grown Radish. After this each divides again into two, and the Clusters are then twenty-four: such as we find them in a full-grown Radish-Root. The whole Clusters are swelled in length; and their white Vessels closely surround the green, and are immersed in the Flesh of the Root, which is also white, and which runs in a kind of rays, intermixed with the Blea, in the manner before mentioned in the Hellebore Flowering-Stalk; but more distinctly.

Thus the Root continues to the point *, where there is, in this state, the short rudiment of a Stalk supporting a Bud. In a transverse section of this rudiment of a Stalk we see the parts much more distinctly. The Flesh loses its white colour and radiated form, which joined to disguise it in the Root, and to confound the view: here it appears of an opaque pale colour, forming a regular line within the Blea; and within it, as is the usual course of Nature, are the conic clusters of Vessels, pointing inward into the large Pith.

THESE are here divided into a much larger number than in the body of the Root; they may be accounted thirty-six; but they are so easily capable of farther division, that it is impossible to ascertain any regular number. The coloured Vessels of these clusters are of a deep green; and the white Vessels which belong to the same clusters, lie behind them. Thus is formed the rudiment of the Radish Stalk on the head of the Root; and from this place it is in the young Plant, we are to trace the origin of the Leaves, whose essential and original part is a portion of those Clusters.

THREE small tubes of the Flesh from the surface of that substance in this rudiment of a Stalk, we have seen push themselves obliquely outward. The Membranes and the Blea go with them; and Vessels from the Conic Clusters of that part whence the process rose, send multitudes of those small hollowed Fibres, mentioned in the Hellebore, out with them. These pierce the base of the three tubes of Flesh, and from these rise new
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Conic Clusters within them. Thus is the first effort made for a Radical Leaf of the Radish.

THE three tubes of Flesh being somewhat distant from one another, the Membranes enclosing them assume a broad shape, and the whole becomes rounded and hollow, in conformity with the shape of the rudiment of the Stalk from which they rose. The tube of Flesh grows thinner by degrees, till soon the Clusters are left alone. The middle one, which runs up the center of the Footstalk, continues single; but the two others which pursue their course along the two sides, presently divide, first into two, then each into four; so that at a small height instead of three, we see five of these Clusters; and a little farther nine: toward the top of the Footstalk they begin to unite again, they become only five, and finally only three, as they set out, till at the very part where the body of the Leaf begins, they sometimes divide into five again, and thus run up the middle Rib.

FROM this part they send off portions in the same manner as these Clusters themselves were first sent off, which being covered with a little Blea, and inclosed between the distended and expanded Rinds, form what we call the smaller side Ribs of the Leaf. In all these portions the Clusters are entire, tho' small. They consist of white and green Vessels. The main Rib pursues its course straight up the middle of the Leaf, till it reaches very nearly the extremity; only becoming smaller all the way it goes, in proportion to the number of Vessels sent off in form of the side Ribs. In the same manner the several side Ribs run obliquely toward the extremity of the Leaf, and terminate in various places near its edges. In their course they frequently inosculate with one another; and from that line in which they terminate near the edges of the Leaf, there are produced small and wonderfully divided Vessels which join the Ribs again.

THE substance of the Leaf between the two Membranes is a thin bed of Blea, which opens its cells to the surface on each side of the Leaf; and the Membranes are constructed just as in the Seed-Leaves. The side Ribs send off a multitude of minute branches; and from the extremities of these frequently rise the hairs of the Leaf: these are few in number, and appear so many pellucid cones, when we view them by the Microscope.

ALL these parts are best traced in an extremely young Leaf, because such a one is more manageable, and more transparent; but they may be seen distinctly in the Radical Leaves of full growth, in the Footstalk of which the three original clusters of Vessels, when a Leaf is torn off at the base, are seen like three thick green cords.

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THE office of these Radical Leaves is plainly the same with that which the two Seed-Leaves originally performed ; to imbibe, and occasionally to discharge humidity ; and to give room for these Vessels of the Conic Clusters to elaborate their Juices. These Juices feed the Plant ; and we see accordingly when the Radical Leaves become more numerous, the Root quickly increases in bigness ; as it swells, the original skin bursts at the point * ; and falls down a part of the Root in two oblong Films.

ALL this is for the feeding of the Root ; for yet the Bud increases scarce at all. Its short rudiment of a Stalk becomes a little lengthened, as it sends off these numerous Leaves ; and they continue till the Root has acquired all its strength and size. Then it takes the part of nourishment upon itself : hitherto it has been fed, now it begins to feed ; and its Juices drawn from the earth, pursuing their course upwards, lengthen the Stalk, and raise the Bud. The Radical Leaves having performed their office, now decay ; and the Bud rises to a perfect Plant.

THE course of Nature in this great operation will be understood with ease, now we have seen it in the two lesser efforts of raising the Seed, and Radical Leaves.

UPON the crown of the Root originally stood a perfect Bud ; the same Bud yet exists, scarce altered, except that it is raised a quarter of an inch more upon a kind of Stalk. We do not see this Stalk till we tear away the Leaves ; but it then shews itself distinct by its green colour. The Leaves are faded ; the Root draws a vast quantity of nourishment, there is nothing to be fed by this but the Bud, with its short Stalk ; and this grows up therefore quickly.

As it rises it sends out some Leaves, in the same manner exactly as those from the original base, which are now dead : but this is not all. The force of the Root is more than sufficient to this purpose ; and at some small height from the ground we see in the bosom of each Leaf a new Bud : this is the rudiment of a branch, as that at the crown of the Root was of the main Stalk : and it has all the seven parts continued to it from the Stalk, as the Stalk itself had them from the Root. Each of these as it rises into a branch, will, in the same manner, send out its Leaves, and Buds in their bosoms without end. Any one of these Buds may be separated from the Stalk, and with good care raised to an entire Plant ; as has been long time since proposed in Shrubs, by the Ratisbon Agricola, and verified by many experiments performed, at my request, by Mr. BARNES. This shews the propagation of Vegetables to be only a continued growth.

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THE manner wherein the Bud for a Branch is produced in the bosom of the Leaf, is this. At the same time that three small processes of the Flesh have projected themselves forward, to form the Tubes for lodging the Conic Clusters in the body of the Leaf, a larger simple portion begins to rise just within them. This grows slower, but it continues to grow; and when the Leaf has obtained its full dimensions, this begins to rise; just as the original Bud at the crown of the Root did, when the Radical Leaves were fully grown.

THE original process in this is a single hollow portion of the Flesh, which raises the Rinds and Blea, and all the other parts with it: Conic Clusters are formed in it, by fine Vessels rising from those in the body of the Stalk, and piercing the Flesh: a Pith is formed within, by the Juices from the Flesh. And here is a compleat Vegetable Body, which needs only nourishment to expand, and give it growth. The Plant being now in full vigour, this is supplied abundantly, and the Bud rises to a new Stalk: which, since it grows from the main Stem, is called a Branch: but if the Bud had been taken off, and planted separate, this would have been called an entire Plant. The parts are not only the same, in the main Stalk and the Branch, but they have the same number and proportion.

THESE Branches send out other compleat Branches, if the nourishment be luxuriant; and toward the summits of all the primary Stalks, and all the divisions and subdivisions of the Branches equally are sent out other processes of the Flesh, which carry also all the other parts off with them, and are Footstalks of Flowers; in which the several coats and other portions terminate. The Flesh in its extream divisions, making the annular Embryo in the globule of Farina; which after being conveyed to the Seed, and in that state committed to the ground, rises a perfect Plant again.

C H A P. XXXIV.

Of the COURSE of the JUICES in PLANTS.

WHAT has been said of the formation of the Seed, and its growth, in the Radish, is equally true in the general œconomy of Plants; for the Vegetable Nature is the same in all. We have seen in what manner the original Juice is lodged in the embryo Plant, and by what means its motion forms the other parts; what remains for an enquiry is its Course in the Plant. This leads to the solution of a famous Problem, Whether there

there be, or be not, a Circulation of the Juices in Plants. The analogy which obtains, in many instances, between Animals and Vegetables, led many to think there was a general Circulation in the one as well the other; and some circumstances seemed to favour it. The opinion was received; tho' rather from probability than experiment or proof: and it kept its ground many years. Dr. HALES overthrew what those Writers had advanced, by an accurate research, and a more certain philosophy: and at this time it is the received system, that the Juices of Plants do not circulate; but that an evaporation, and absorption, during the alternate changes of day and night, answer the purpose.

To determine that there is no circulation in Plants, because we are able to overthrow the reasonings on which certain Authors established their opinions that there was one, is rash: for the fact may be so, tho' these have failed in the support of it. On the other hand, to question facts so absolute as those advanced by Dr. HALES, were most absurd. The question has not yet been rightly stated: nor is it necessary that one of these two systems should overthrow the other. There may be a returning course of the Juices in a Plant; tho' not universal, nor like the Circulation in Animals: and this may be so far from opposing or disturbing the system of Evaporation and Absorption, that it may conspire and coincide with it in the œconomy of the Plant. Reason cannot deny that this may be; and I persuade myself experiments will shew it is. This is the system I would propose to the world; and I flatter myself they will receive it, so far as evident facts, and plain experiment, support it.

THERE can be no wonder that this was not found before; for by some strange fatality the parts wherein it is transacted, have been in a manner unknown: the Flesh of Plants having been very imperfectly understood; and those conic Clusters of Vessels, so essential to the being of the Plant, not having been discovered. The useful method will be, to trace the Juices and their course, along the Vessels of these parts, in Plants of various kinds, beginning with those of the least complex structure, and advancing to the rest by gradual stages.

IT is the course of Nature that in the Seed is lodged a piece of the Flesh of the parent Plant; and that when this is sown, and takes its growth, the termination of the whole is in new Seeds, in which are lodged also such pieces of the Flesh in the same manner. We are therefore to trace the continuation of this Flesh, and consequently the course of its Juices from the body of the Root, which is the first growth of the Seed, to the

Flower; and we shall find this route very short and simple in some Plants, and long and complex in others: it is therefore we are to select the distinct kinds. We shall begin with the Colchicum, which consists only of a Root and Flower. In this therefore the course of the Juices is shortest and simplest of all: from this we shall advance to the same enquiry in the Winter Aconite, which has a Flower-Stem between the Root and Flower, tho' no proper Stalk; the next advance will be to the Anemone, which has a proper Stalk, with a peculiar Leaf; and from this the course will be easy to all the rest.

C H A P. XXXV.

Of the COMMON COLCHICUM.

THE common Colchicum, in its state of perfect growth, consists only of two parts, the Root and Flower; the Flower being fixed on the Root, without any intermediate Stalk; and no Leaves rising with it. See Plate X. Fig. 1.

ALL Plants we have seen consist of the same constituent substances, Bark, Rind, Blea, Flesh, and the like; and these equally have place in the minutest Fibres of a Root, and in the Stem. Here being no Stem, we shall have an easy opportunity to see what these substances are, and what becomes of them. The system of solid Bulbs will be also discovered in this examination; for no Plant is more truly of the solid bulbous kind than Colchicum.

A PLANT of this kind, taken entire out of the ground in Autumn, when it is in full Flower, appears thus. An oval, but somewhat irregular, bulb, lengthened into a neck at the top, and in the same manner lengthened on one side at the bottom, is the most considerable part. This is covered with a thick brown Skin, and, from two distinct parts, it sends out Fibres; a large cluster from each. One of these clusters proceeds from the lengthened end, a; and the other from the opposite side of the Bulb, b, where it seems naturally to have terminated. From the neck at the top of the Bulb, bursts out the tube of the Flower. Superficial Writers have called it a Stalk; but it is in reality the body of the Flower itself, not yet divided into segments. At a small height above the ground, it is divided into six of these, and opens into a large Flower; which has no Cup:
the

the outer Films of the Bulb having served that office while it was in the ground.

THIS is the whole exterior appearance of the Plant: and Gardeners think, the single and solid Bulb alone remains always; sending up yearly its Flower in Autumn, and ripening its Seeds under covert of the Leaves in Spring. The two clusters of Fibres might have given them other thoughts; but to understand the matter truly, we must uncover and dissect the Bulb.

ON opening the outer Coat, and turning it back, we find in the centre a solid oval Bulb, with a large process on one side, and a shorter on the other: along each of which runs a cluster of Scales, covering the Rudiment of a Flower. This is represented at Fig. 2. If we separate the solid part from these Rudiments, and its Shell, we see it entire, with a crown at the head, and another at the base, from neither of which any thing grows. This is represented at Fig. 3. At 4 is the entire Plant split lengthwise: at 5 and 6 the solid body of the Root cut transversely. At 7, the Seed-Vessel entire, surrounded with its Spring Leaves: at 8, the Seed-Vessel alone, divided, to shew the arrangement of the Seeds. This gives a general view of the structure of the Plant; and to these several parts we shall refer in the succeeding explanation.

THE most advantageous way to begin our examination, is, to cut the Root regularly thro' the middle; and then to continue the division strait thro' the center of the Flower. See Fig. 4.

A TRANSVERSE section shews the body of the Bulb a solid substance, irregularly oval, and marked on each side with a deep depression, Fig. 5; in which has run up the tube of a Flower, covered with Films, Fig. 2, a a. The outer coat of the Bulb is found to be a mere thick Film, connecting these three parts together; and it is plain, that the two clusters of Fibres grow from the bases of these two Tubes of Flowers, a a, Fig. 2, not from any other part. These fall asunder in the divided Plant, 4, there being nothing to unite them. They are not fastened to the Bulb in this part; only pressed against it by the outer Membrane.

CLEARING away the outer Coat from the bottom of the Root, we see, that on one side the base of the flowering part is level with the proper body of the Bulb, Fig. 4, a: but on the other, this part being much longer, the very substance of the Bulb accompanies it in a kind of horn, Fig. 4, b. The base of the tube of the Flower, and the horn of the Bulb, are absolutely united in this part; but the Fibres are fixed only to the base of the tube of the Flower; not to the horn of the Root.

ON splitting the lower half of the Bulb lengthwise, Fig. 4, along the centers of the two flowering parts, we perceive all distinctly. The longer process of the Root, c, is joined to the part from which the Flower rose this season, b: and there is another shorter process, d, joined to the opposite Shoot, which is to flower the Autumn following. If we examine the longer process, it is formed thus: a white firm substance, like that of the body of the Bulb, constitutes its lower part; and this is marked with three white lines in the center. Upon the head of this grows a larger and looser substance, Fig. 4, e; and from the head of this rises the Tube of the Flower. That oblong and loose substance is properly the Receptacle of the Flower, analogous to what we see in the other Plants.

THIS is the construction of the part which furnishes the Flower of the present Year; and that on the opposite side of the Root, is no way different, but by being younger. The Fibres have a small thin head close under the Receptacle of the Flower, Fig. 4, f; and this head, with those Fibres, constitutes the proper Root of the Colchicum: the Bulb is no Root; nor does it produce any thing. How far this may be the case in other solid Bulbs, deserves enquiry. In the coated kinds it is quite otherwise; the Bulb there is a Bud: the young Plant lies in its center, and the Fibres or Coats fall off as it rises to perfection; but here the Bulb contains no Rudiment of a Plant; nor is it a Bud, or any thing of that nature. It is a Placenta, furnishing the real Roots with their first nourishment.

WHEN a Seed of Colchicum is sown, its first produce is the part f, Fig. 4. The small head of the Fibres, to which is connected the Rudiment of the Bulb. This penetrating deeper into the earth, drags down a part of the Bulb with it, which forms the horn or process, a, Fig. 3. The body of the Bulb, Fig. 3, b, keeping its place higher: and at the very base of the flowering part, Fig. 4, f, there is that thin original yellowish callous substance, which is the proper and original Root of the Plant, and furnishes the Fibres. This thin callous part is continued up the process c, Fig. 4, along the base of the Bulb, Fig. 4, g, where it forms the little head in the center, h, and from thence continues its course in the same thin form, to the opposite side, where the little head, a, Fig. 4, is produced: this is properly a Bud for the succeeding year; and it contains the Plant in miniature, which is then to flower.

THIS is the true condition of the Colchicum: while the Plant, Fig. 1. is about to flower, the Bud, Fig. 4, a, is formed; and when the Flower, Fig. 4, b, has ripened its Seeds, and perishes, then the Bud, Fig. 4, a, rises,

and flowers, and a new Bud is then formed at g, Fig. 4, the Rudiment of which is fixed on the opposite side of the Bulb.

ALL this time the original Bulb remains. It is produced by the Root; and it produces nothing: it is to the infant Plant what the Placenta is to Fœtus's in the animal kinds; a large body, of a fleshy substance, prepared to receive and detain Juices for the nutrition of the Embryo Buds. This solid part of the Root, which is the true Bulb, is represented separately from the flowering part at Fig. 3. When it is cut thro' perpendicularly, as at Fig. 4, there appear a few dusky lines, which makes it seem composed of so many coats; but the transverse section, Fig. 5, shews these are only courses of Vessels.

THE new Buds for flowering strike their first Roots into the very substance of this Bulb; piercing it to a third part of its thickness: this appears by a peculiar white part in the Bulb near the Bud, Fig. 6, a. These are utterly distinct from those Roots which the Bud forms afterwards, and thrusts into the ground: and this more distinctly proves, that the solid body of the Bulb is a Placenta, containing no Rudiment of a Plant, but affording nourishment to the young Buds.

ALL this is shewn in the divided Flowering Plant, at Fig. 4, distinctly. The Bulb, *i*, is placed between two Rudiments, *a*, *b*; and being furrowed on its surface, as is shewn at Fig. 5, it makes a soft bed whereupon they lie. They are connected with it at the head, whence the Fibres arise, and no where else. The Flowering Shoot, *b*, has all its parts distinct; and is furnished by its proper Roots with nourishment: the Shoot for the next year, *a*, is furnished partly by its proper Fibres, and partly by the Roots it sends into the body of the Bulb, as at Fig. 6, a. The third is furnished from the Bulb entirely.

IN the Flowering Shoot, *b*, there is united to the head of the Fibres, or proper Root, *f*, a fleshy base; and from this is produced an oblong Receptacle, of a spongy substance; from which immediately rises the Tube of the Flower, including in its base the Seed-Vessel. The Tube runs up to a considerable height; and within it are carried up three lesser Tubes, the three Styles of the Flower: all these are covered with many Films, which were the original defence of the Bud: the outer ones decay and fade; but the inner ones afterward grow out into Leaves, and serve to defend the ripening Seed-Vessel. From the upper part of the Tube of the Flower rise six Filaments; which shew the class of the Plant.

IN the Bud for the succeeding year, a very good eye may trace some Rudiment of the minute future Plant; and powerful Glasses shew it more distinctly: but in the third Bud scarce any thing is seen.

AFTER a time the Seed-Vessel enlarges; and the Receptacle growing up in length, becomes a kind of Stalk: the inner Films, which surrounded that and the Flower, also grow up into Leaves; see Fig. 7: and those who would have at first supposed the Plant produced Flowers without Seeds, would in this state of it imagine, that it ripened Seeds with no preceding Flowers, the time being so distant; and no appearance of the one accompanying the other.

IT is a question of importance, where resides the Vegetative Soul, or Principle of Life in Plants: we have allotted it, in general, to the Flesh of the Plant; and examples are to prove this. Where there are so few parts, as in this, we shall be most likely to find the certainty.

THE Seat of Life here is not in the solid Blub; for that produces nothing: and is a mere reservoir of nourishment: it is not in the Flowering Shoot, for that consists of perishable Films: nor is it in the Fibres, for they will decay, and yet the Root will grow.

IT is therefore, and it can be, only in that thin yellowish callous head of the Root, which sends out the Fibres from below, and from which, above, the fleshy base of the Receptacle rises.

THIS always lives, and remains, so long as there is a power of Vegetation in the Plant: this is continued under the base of the Placenta, which is called the Bulb; and from the other parts of this thin head are sent up Buds, whose several substances terminate in young Plants; and which piercing, by peculiar Roots, the substance of the Placenta, draw their first nourishment from thence; and afterwards send out Fibres.

IN this thin head of the Root, we may distinctly see, by the Microscope, all the seven constituent substances of Plants, and we may see them also in the Fibres. In the upper growth, the two Rinds make the Films and Leaves; and the Blea, with all the rest, rise, as usual, to the Flower.

THE Principle of Life is a plain, simple, fleshy substance; perfectly uniform, and covered by its proper Coats: from this rises upward, a fleshy base, less solid than the Root; but of its nature, and with all its coverings: from that a Receptacle rises, like the first, but yet more spongy; and this forms at its top a Seed-Vessel and Seeds; all of the continued substances; which no Stalk supports, nor no Bark covers. The body of a Flower rises round it, formed of the thin Blea; and the male parts grow from this, as the Styles,

Styles, or female parts, do from the Seed-Vessel. When the Flowering Shoot has ripened its Seeds, it decays entirely, and the base of the Root forms new Buds, for succeeding years, round about the Placenta.

ALL Authors have perceived there was something wonderfully singular in the Root of Colchicum. DIOSCORIDES mentions the hollow all along the middle of the Bulb or Placenta, *διαφυσιν μεσην*, from which the Flower rises: and TOURNEFORT expresses himself very singularly: he says the Root is double, and of two kinds; the one fleshy, and the other fibrous, or fibrated; tho' both enclosed in one common Rind. Nor does he call it properly bulbous, but tuberous; *Gemina tuberosa, altera carnosa altera Fibrata*.

INDEED the construction of this part of the Plant was never sufficiently understood; nor is it truly bulbous.

IF we would gather knowledge from an observation of nature, we must first understand the objects. The candid reader will pardon, therefore, this detail; without which the course of the Juices, in so simple a Vegetable, could not be understood; and every part of which, tho' new, is certain. It is a custom in this idle age, for men to doubt what themselves have been too careless to discover: but this Plant is common, and all that is said of it may be seen easily.

WHEN the Seed of Colchicum is sown, if we take it up after a few days, we may see easily, that its Principle of Life, or Plantule, is an elliptick ring of yellowish Flesh, altogether like that of the callous head of the Root of an old Plant. This Ring is composed of Vessels in which there is a portion of the original Juice; and there are Valves in them, as in the Hellebore, which open only one way. When moisture from the earth enters the Seed, the Juice in its Vessels becomes thin: the alternate dilatation and contraction, from the effect of heat and cold, pressing, and again relaxing the whole substance, puts that Juice in motion: there is but one way it can move, because the Valves will open to give it passage no other: therefore it runs forward in that direction.

THE Vessels of this portion of Flesh are so many elliptick rings every one returning upon itself, as we have seen in the Plantule of the Seed of Radish. Therefore the essential Juice of the Plant is not driven along Arteries, and returned by Veins, as in an animal body; but merely goes round in the same Vessel.

THE additional moisture from the earth increases its quantity: it swells the Vessels, and the whole Ring enlarges: some part of it is, by the same force, pushed thro' their pores inward; and this hardening on the surface, forms

forms Vessels: hence arise the Conic Clusters, and afterwards the Pith. At the same time some part of their Juice is, by the same means, forced also outwards; and this, hardening upon its surface, forms also other Vessels, which constitute first the Vascular Series, and then the Blea and Barks.

WHILE these parts are all very thin, and before they are well visible, Tubercles rise on the surface of the original Ring, which is now become the Flesh of the head of the Root; and these extend themselves by degrees to Fibres; and upwards, under the covert of several Films made of the continuations of the two Rinds, rises the Receptacle of the future Flower. This Receptacle is formed of the spongy parts of the Conic Clusters, and is covered with a light coat of Flesh: not that the whole Flesh rises in that form; 'tis only a part of its surface; and from and thro' this Receptacle are continued the several parts of the Flower.

In all this the course of Nature is the same as in the Hellebore, only that in that Plant the Receptacle of the Flower is placed upon a Stalk; and in this it rises from the immediate head of the Root. A piece of the head of the Root magnified, with the Fibres and Receptacle rising from it, is represented at Fig. 9. And as the construction here is so extremely plain, the whole will be understood easily.

In this Figure, the circle or ellipsis, *a*, which is of a yellowish colour, represents the Flesh or callous substance in the head of the Root. This was originally the elliptick Ring or Placenta in the Seed. It has formed, by extravasation, the Conic Clusters, *bb*; which are scarce visible in this section, and the Pith, *c*, which makes the inner Substance.

It has also formed the Vascular Series *d*; and the Blea, and two Rinds, *e f g*, outward: and while the Placenta, which has been supposed the Root, is but yet beginning to appear, this has sent down Fibres, *b b b b*, and upwards the Receptacle, *i*, crowned with the Bud, *k*.

BOTH the Bud and the Fibres have been originally produced of parts of the Flesh, *a*, sent off from its surface; and they yet hold communication with it; for their Vessels are continued into it, and are, indeed, no other than certain elongations of a part of its own Vessels. The purpose of the Fibres is to draw nourishment from the earth, and to feed the Shell, *a*, from which they arise: and from the abundance of the nourishment which this part receives from them, it rises in a larger form at the Crown, giving origin to the Bud with its Receptacle, and close to it to the Placenta, *l*.

THE Fibres, which are continuations of the Flesh and its coverings, are perfectly suited to draw nourishment; and from this nourishment is fed the rising Bud: but it does not go crude thither: it is elaborated in the shell



shell of Flesh, *a*; and from other Vessels, not from those by which it was received, is conveyed to the Bud.

THUS the shell *a*, which is the Flesh of the Plant, as it was the original of all, continues the only source of all; and while there is a motion of ascent, evaporation, absorption, and descent, in the whole Plant thus formed, there is also a circulation of Juice in the shell or coat of Flesh *a*, which gives the great force of ascent for evaporation of the useless fluid; and all the time elaborates the Juices for nourishment. In the Coat, *a*, which is the Flesh of the Plant, there is a system of circulatory Vessels, which perform their office all the time that the absorption and evaporation are continued; and these Vessels, whose Juices pursue their own course, are fed by the Fibres, and feed the Bud, tho' with an improved nourishment. This is therefore, a kind of middle portion between the parts for drawing nourishment, and those for growth, preparing the Juices for the one, which it receives from the other.

THE Juices which the Fibres receive from the earth are watery; but those in the Body of the Plant are coloured, scented, and of peculiar taste: they receive this change in the Shell, *a*, which is the Flesh of the Plant; and this is its great office.

LET it not be objected here, that Fibres of Root also have taste: they do not receive Juices thus endued with tastes from the earth; these Fibres have their Flesh, and Conic Clusters, as well as the body of the Root, as we have shewn in Hellebore; those parts are continuations of the Flesh of the body of the Root, and have Vessels connected with its Vessels; it is in these parts the taste, the smell, and other qualities, reside: and as they are in those Juices which have passed the circulatory system in the Shell, *a*, these parts must have the same taste, flavour, and other qualities with the Bud, *i*, or other ascending parts; for they are in the same manner connected with the Shell, *a*, and possess its qualities. It is in that Shell the taste, and smell, and colour, and virtues of the Plant, originally lie: for in the Vessels of that Shell was lodged the portion of Juice of the parent Plant: this gives its tincture to the rest that is received: and thus all the parts which arise from that Shell, have the qualities of the parent Plant, the Fibres not excepted. This is as sure to be the case as if they were portions of the parent Plant itself; for there is no other way in which that Plant gave taste and smell to all its parts.

WE have seen in the Hellebore what is the composition of a Fibre of a Root; and those of all other Plants are of the same structure. The course of the nourishment they draw is so short in this Plant, and the

parts thro' which it passes are so few, that we may with little difficulty trace it; and yet as there are all the proper parts of the vegetable fabrick, we shall, by such an examination, see the whole system of the nourishment of Plants.

A QUANTITY of moisture is to be received from the earth and air, from the nourishment of the Plant; and of this such a Part as is fit for that nourishment, is to be separated from the rest, and conveyed to the several parts which are to grow: the rest is to be discharged. This is the intent of Nature: we have seen the organs by which it is to be performed; and we are here to trace the manner.

THE Fibres have Flesh, with Conic Clusters, and a Vascular Series arising from the same parts in the body of the Root; but they have also a Blea, and two Barks; which tho' they have like the rest arisen first from the Flesh of the body of the Root, yet do not return into it again, as those just named, but pursue their plain course over it, from one extremity of the Plant to the other. This is the distinction of those separate arrangements of parts; and the course of their Juices appears to be this.

THE outer Bark of the Root runs down the Fibres, and up to the crown of the Bud, where it terminates in a kind of Films. This Bark, while the Fibres are surrounded with the moisture of the earth, receives that moisture thro' its spongy surface, and into all its Vessels. These are so many extremely minute tubes, up which the fluid ascends by the attraction of their sides; and in this ascent it is greatly assisted by that compression and dilatation which arises from the continual change of temperature in the air. The course of these Vessels is over the body of the Root, and up to the summit of those Films wherein this outer Bark terminates. They are spongy here as elsewhere, and the Juices they contain can easily pass in part thro' their surface.

DURING the warm hours of the day there is a constant evaporation of part of this Juice of the outer Bark from the Films; and by this means the Vessels are often emptied, faster than they can be supplied by the Fibres. On the other hand, when the heat of the day is over, and this evaporation ceases, a new operation obtains in the same parts: the air grows damp, and the spongy surfaces of those Vessels which are exposed to it, can as easily imbibe as they could before perspire: therefore a great quantity of moisture is, during these hours of the night, taken in at the surfaces above ground, and makes its way, in some measure, down the Vessels.

THIS seems to be all the absolute motion of the Juices in the Vessels of the Bark; and if so, it has been very idly supposed to be circulatory: yet

as there is reciprocal rise and fall, it may affect all the changes in the Plant, which the favourers of a Circulation have supposed to be proofs of that motion. This the philosophy of Dr. HALEs established, and all experiments prove it. But there is something more.

THE inner surface of the Vessels of the Bark is covered with Glands : these secrete a somewhat richer part from the common watery Juice, during these its motions : and they discharge it, thro' apertures in the Membrane, into that small cavity which there is between the outer and inner Rinds. Thus while a great deal is received, and again evaporated, some part is separated and detained. To know what becomes of this, we must recollect the structure of the inner Rind of Plants.

THIS inner Rind of the Fibres of Roots absorbs also from the earth ; for the outer Bark is too thin and too spongy to prevent the passage of the moisture. The Vessels of this inner Rind open by many mouths into the space between it and the outer, and there receive that part of the Juice of the Vessels in the outer Bark, which had been secreted and discharged thro' their Glands. The nourishment therefore received by the Vessels of the inner Rind from the earth and air, becomes enriched by this secretion ; and in the same manner its Glands, after a second elaboration, deliver it to the Vessels of the Blea.

THE Blea is composed of Cells, which receive moisture from the earth and air, as do the Vessels of the two Rinds ; and from this also a part is concocted by the Glands of those Vessels, and received into them. The Blea ascends to the surface of the earth, terminating in a kind of shell over the Bud, as the inner Rind terminates in Rudiments of succeeding Leaves. Both these parts go over the thin body of the Root ; and in the Vessels of both there is the same ascending motion of the Juices in the day, and descent at night : but there appears in the construction of the Blea a manifest and essential difference from theirs.

THE watery nourishment, and this secreted richer fluid, flow together in the Vessels of the inner Rind ; but in the Blea it is otherwise. The cells of the Blea hold the watery Juice ; and its Vessels contain only this secreted fluid, which is, by these various operations, become high coloured, thick, and of some taste and smell.

THIS rich Juice from the Vessels of the Blea is discharged thro' Vessels, which pierce the Membrane of the Vascular Series, into the Shell, a, which is the Flesh of the Plant : nor does that part of the Plant receive nourishment any other way.

THUS, after three concoctions, a nutritious Juice is delivered to the Flesh of the Plant: this Flesh is composed of Vessels in which there is a circulatory motion; extremely simple indeed, yet capable of producing great effects. Here this additional Juice is mixed with the original Juice of the parent Plant, and goes this short round many times with it. It feeds and increases the Pith, and the conic clusters of Vessels, by what it sends into them; and the remainder being perfectly assimilated and blended with the proper Juice of the Flesh, becomes one substance with it; and by increasing its quantity, gives it new force for growth.

THIS force is directed to the points *m m*, in the present instance; and there a part of the surface of the fleshy substance of the Root rises, and forms the origin of the Bud. The Coats are continued over it, as in the Hellebore; and the two Rinds terminating at the surface of the ground, in Films and Rudiments of Leaves, which are long after to appear, the Blea is forced up higher, by the ascending Flesh of the Bud; and the whole rises together into the Tube of the Flower, *b*, Fig. 4; at whose summit, just where it divides into Petals, the Flesh separates and bursts in Filaments, whose termination is in the Antheræ; and in every globule of Farina contained in those, there is the elliptick Ring, which is the absolute termination of the Flesh in that part.

WHILE this is transacting in the upper part of the Flower, the Pith of the Receptacle rises into the form of a Seed-Vessel, and gets its needful Coats. The base of the Flower, and the numerous Films, defend it from all injuries: And thus, in a long course of time, it ripens, under the earth, those Seeds, into each of which a perfect globule of the Farina has penetrated, thro' one or other of the three Styles of the Flower. This passage is long, but it is not difficult. The heads of the Styles are placed below the Antheræ, and conveniently for receiving the Farina as it falls: they have considerable hollows, always moist; and the globule of Farina is smooth and small: the passage is perpendicular down, and therefore it makes its way more easily. When it has got into the Seed, all is concluded, and the growth follows as plainly and naturally as in the Seed of the Radish, tho' much more slowly.

WHILE this essential business is transacting in the flowering Plant, Nature, tho' slow is not idle with regard to the future Seeds. They, and the Vessel which contains them, are to be nourished as well as the Flower, tho' at a different period of time, and their supplies are now provided.

WITH the embryo Bud for flowering there rose at the first shooting of the Seed a single grassy Seed-Leaf, which receiving some processes from
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the conic clusters of Vessels in the head of the Root, and being formed within, as the Seed-Leaves of the Radish, serves to keep up a return of Juices and to absorb moisture from the air; and thus to assist in feeding the Plant. This fades as soon as the Bud is well formed; and then begins a new growth, for the assistance of the Seeds: the great Placenta, the first rudiments of which appeared early in the Seedling Plant, now grows faster; and the Films in which the inner Rind of the Root terminated, begin to grow in length, and to loosen themselves from the head. These, however, make but slight advances during the appearance of the Flower, which does not want their assistance; but when it has faded, they shoot faster; and when the Seed-Vessel begins to swell, they pierce the surface of the ground, and make so many Leaves. This is the state of the Plant represented at Fig. 7.

THE construction of Leaves has been shewn in the preceding Chapters, in the Seed-Leaves of the Radish. All Leaves have the same general formation, and the same use. The disposition of those Conic Clusters which make what we call the Ribs, constitutes all the difference: They have Vessels which go and return, as those in the Flesh of the Plant from which they proceed, and with which they communicate; and they are formed principally of a Blea with open cells, which discharge and absorb, occasionally, the moisture of the earth and air. These Leaves are raised for the defence and nourishment of the Seed-Vessel: they therefore do not appear till that rises above the ground; and having served its purposes, they fade. The Seeds are then ripened, and are fit for a new produce; but as many of them must fail in the uncertain way wherein Nature sows them, the Root remains to supply the deficiency.

C H A P. XXXVI.

The COURSE of the JUICES in the WINTER ACONITE.

THE Plant commonly known by this name, WINTER ACONITE, is properly of the Hellebore kind: Its singular Nectaria, its want of a Cup, and its Seed Vessels, shew this evidently; but while the distinctive characters of Plants were less regarded, the fancy of Writers gave it this name; which custom still preserves. It makes a natural advance from the Cholchicum, in the Vegetable Composition; being somewhat more complex than that; yet less so, by many degrees, than the generality of Plants.

WE

WE have traced the course of Juices in a Plant wherein they made a very short circuit, having only the head of the Root, the Bud for flowering, and the Fibres, for their sphere of motion, during the flowering state: In this Plant the Flower has its Stalk, and there are distinct Leaves upon their Footstalks; as well as a large Leaf immediately under each Flower: therefore here is a larger circuit for Circulation, and more compass for observations and experiments. There is also the advantage of larger parts, in which every thing is more conspicuous.

WITH this Plant before us, we may form some idea of the extrem simplicity of the other. It will appear, by the observations we shall have opportunity to make, on the Anemone, and the more complex Plants, that beside, and beyond the systems of Circulation, there are continued certain growths of the Plant, in which the reciprocal actions of evaporation and absorption alone take place: and, in some degree, the same thing is, indeed, the case even in that species; tho' the whole scene of action in this respect, is there confined to the Flower. The system of circulatory Juices there, is carried no farther than from the Receptacle of the Flower to the Fibres: the whole Flower being fed from that system, and serving as the Leaves, and upper growth of other Plants, to perspire in the day, and, in some degree, to absorb in the night, the watery Juices. This, therefore, was what we called the first and simplest course of the Juices in a vegetable body: in the ACONITE we find a second: for tho' there is but one system of Circulation in the Flesh Vessels in this Plant, which is carried on in the body of the Root, and which feeds all the rest of the Herb; yet there is a partial return of Juices to this absolute system, by means of those Vessels which run into the Leaves; and which, as in all other Plants, return again into the Flesh of the Root from which they rise.

THIS may explain the purpose wherewith the WINTER ACONITE was chosen for this place: but to understand all the particulars, we must first entertain a distinct notion of the construction and several parts of the Plant.

THE WINTER ACONITE consists of five parts, 1. a Root; 2. Radical Leaves; 3. a Stalk; 4. a Leaf, which has served as a Cup to the Flower Bud; and 5. the Flower.

THE Anemone, of which we shall treat hereafter, has originally such a Leaf, serving as a Cup: but when flowering it rises by a new Stalk from that CUP-LEAF; the Flower of this, on the other hand, remains always close upon its bosom. The entire Plant, in Flower, is represented at Plate XI. Fig. 1.

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THE Root, Fig. 1, a, is brown, oval, tuberous, and lies nearly horizontally in the ground; sending long, pale brown Fibres every way upward, downward, and on each side. On splitting this lengthwise, together with the Stalk, as at Fig. 2, there appears to the unassisted eye a white solid mass, a, with a yellowish circle, b, in it; and covered with a brown Rind, c, from the head or crown of which rises a Stalk, d, among some Films, e. The Microscope discovers in this all the essential and constituent parts of a Plant, ranged in the following order. 1. A very thin, brown outer Bark, which is a mere Film. 2. A pale inner Rind, three times as thick as the former. 3. A white Blea, of a spongy texture. 4. A Vascular Series. 5. a Fleshy Substance, moderately thick, and of a pale hue, with a tinge of yellowish. 6. The Conic Clusters, small, and greenish. And 7. within these the Pith.

THE part of the Root next the crown shews these several substances most distinctly: they gradually blend with one another toward the base; and only a powerful Microscope shews them. In a slice cut so thin as to be transparent, the outer Bark is thus seen to be vascular; the inner Rind absolutely spongy, from the number and largeness of its Vessels; the Blea is cellular, but the cells are small; the Vascular Series is considerably thick; the Fleshy Substance contains fewer Vessels, but those plain, large, and distinct; and from the sides of these shoot branches, which run into the other parts: the Conic Clusters are small, and nearly oval: and the Pith is an absolute sponge; it is composed of Vessels, in whose cavities we see a thick fluid, joined like beads in a necklace; and of a great deal of loose white matter between them.

FROM various parts of the Root arise Buds, which, by degrees, grow to a sufficient bigness for parting from it; and forming new Plants. These all rise from the Fleshy Substance; and raise with them all the other coats: but they have no connection with the Pith. They are sent off from the outer surface only of the Fleshy Substance; and they soon shoot inwards a Pith of their own. They take coverings also from the three Coats they carry with them, and each Offset has a Rudiment of a Plant in its Crown, covered by scaly substances, formed of the ends of the several Coats.

THE Fibres of the Root have the same origin with these Buds: they arise plainly and solely from the exterior surface of the Fleshy Substance, which sends out a part of its thickness into them; the main body of it pursuing its own course, round the Root; and these Fibres also soon shoot inward a Pith of their own; and taking with them Coats from the three
outer

outer substances, they become continuations of the body of the Root itself, except in regard to the Pith; each forming a Pith of its own.

THIS is the construction of the Root; and in this it is easy to see that the Fleishy Substance is the essential part; the Seat of Vegetative Life, and source of all the rest: if we begin to trace it at the very crown of the Root, Fig. 2, f f, we see it form a thick yellowish line, which lies under three coverings; and pursues its course to the very farther end of the Root, g g: it does not terminate or break off there, as has been supposed by former Writers, but pursues an uninterrupted course round that end, and returns up to the Crown, f f, again: it increases in thickness as it rises toward the Crown; just as it decreased going the other way from thence.

THE reason of this is plain: it is entire at the Crown; but in its course toward the base of the Root, it sends off Vessels to the other Coats; and Pith, and the Fibres also for drawing nourishment. These being a part of its substance, reduce all the way its thickness, till at the base, g g, it is a mere line, yet perfectly distinct. This has not been heretofore observed; but a great deal depends upon it.

THE Seed of the Plant first forms this Root: its Heart, or Plantule, as people have idly called it, is an original annular piece of the Fleishy Substance, from the Stalk of the parent Plant: this swelling with the moisture, and growing from the warmth, in the bosom of the earth, first extends itself in bigness, shooting a Pith within, and Coats without, for its defence; and while this is doing, Fibres, h h, are also sent out to seek distant nourishment; and Radical Leaves, i i, to assist the course of the Juices. The origin of the Fibres we have seen: and these compleat what is called the Root. The rise of the Radical Leaves, the second part of the Plant, we are now to examine.

WE have seen, in other instances, the outer Coat of the Root continued up in form of the outer Bark of the Stalk; but here it is otherwise. In the generality of Plants the Stalk consists, like the Root, of seven parts or substances: but in this the entire Stalk is composed only of six. It rises from within the crown of the Root; and no outer Rind is continued to it.

THE Footstalks of the Radical Leaves, i i, have the same structure with this Stem: and they are thus formed.

THE outer Bark of the Root terminates absolutely at the Crown, f f. As mere a Film as this seems, powerful Glasses shew it to be Vascular, as in other Plants; and it has two Membranes, containing the Vessels. We see this in its termination in the part just named. Its office is to cover the Root only; and that being performed, it splits into a kind of scales, e e,

at

at the Crown. The outermost of these two Films which cover its Vessels, and which is dark and rugged, breaks irregularly at that part, and the ends of abrupt Vessels are seen a little beyond. The inner Film is paler, and it is carried something farther: it splits like the first into irregular flakes; the principal of which make a kind of scabbard for the embryo Leaf.

THIS rises from a small point on the surface of the Fleishy Substance of the Root; which pushing outward, at length forms a Rudiment of a regular Leaf, faint and yellow in colour; which shooting above the ground, is covered at its base by this scabbard.

ITS Stalk is formed of the Blea, or third substance of the Root, covered with the inner Rind; so that it has two Coats; the outer one very thin, and green; the inner thicker, and whitish. The Fleishy Substance of the Root pursues its course entire under the base of this Footstalk; but it sends up into it a small tubular portion, as in the Seed-Leaves of the Radish; which dividing into six parts, covers so many Conic Clusters of large and firm Vessels, of the same yellowish green colour. These are carried up at distances within the hollow of the Footstalk; and that hollow is then filled up between them by a kind of Pith: this is not continued from the Pith of the Root, for the course of the Fleishy Substance cuts off all possible communication of that kind; but is formed originally from this Fleishy Substance at the base, as the Pith of the Root was; being truly the white part of these Clusters of Vessels. The first Pith is formed of small Vessels, shot inwards from the Fleishy Substance of the Root; and this of the Leaf-Stem is formed of the same kind of Vessels which the same substance sends, outward and upward, in that part where it is divested of its Blea, and Bark, by the Shoot of this hollow Footstalk, which is formed of them, and so far taken their place. Where they cover this Fleishy Substance, they have been formed from it, by extravasated Juices; and in the same manner where a tubular Footstalk of a Leaf is formed, this Pith rises upwards within it, making a kind of soft bed for the six great clusters of Vessels. It is sent up in the same manner as sap will rise from the stump of a Birch-tree up the nose of a tin funnel, till it fills the whole hollow; altho' the funnel be raised perpendicularly upon it. These Vessels of the Pith are nothing more than small streams of the Juice, whose surface has hardened: they arise cylindrical; but their sides squeezing one another, they become in the end somewhat hexagonal.

THUS the Fleishy Substance of the Root is also the essential part of the Footstalk: for the six clusters of Vessels are formed within, and covered

by a tube of that essential part; the rest is only their support or covering. A view of these six Clusters, as they appear in a thin transverse section of the Leaf-Stalk, is shewn Figure 3.

THESE six Clusters of Vessels run strait up to the base of the Leaf, where they make a small Gland; and thence are carried along the principal divisions, in form of Ribs; sending other small branches from them, which again return into them. The body of the Leaf is composed of the entire Stalk, expanded into that form. The Membranes which cover it make the upper and lower Skin, and the white part of the Vascular Clusters separated from the rest, supports the Vessels along the middle.

WE see, therefore, that this Leaf is no more than a production in length of certain parts of the Root; and may be considered as one entire Gland, serving for the secretion and preparation of a certain Juice, needful afterwards for the furnishing the Flower, and for the evaporation, and absorption of moisture. Its communication with the Root is open, and evident; and this is its plain use. The Leaves of many Perennial Plants, while young, answer the same purpose; and there are two seasons wherein they grow and decay again, while the Flower is yet in the Bud, at the crown of the same Root. This is very evident in the Seedling Anemones and Ranunculuses.

WE come next to examine the third part of this Plant; the Flowering Stalk, Fig. 1, b. This differs little in external appearance from the Leaf, and its Footstalk; only upon its center rests a Flower. This Flower-Stem rises from the crown of the Root, by a narrow neck. The outer coat of the Root is thrown off entirely at the Crown, making a scaly Bud, and a kind of scabbard for this Stalk, at its rising: but all the other substances, the Flesh in part and the rest entirely, are continued to it, except the Pith.

LET the curious, who follow these experiments, make careful sections of the Plant: for the same body, cut in various directions, affords different appearances; and the slipping of a knife might accuse this account of error. Let the Stalk be cut thro' transversely, and split perpendicularly near the crown of the Root, and things will be seen as at Fig. 4, and at the Letter *d* in Fig. 2. The inner Rind of the Root makes the outer covering of this Stalk; but it is in this part reduced to an extream thinness. Within this appears the Blea; which is white, vascular, and somewhat thicker. Within this lies the Vascular Series, then the Flesh, and within that the Conic Clusters; then, in the midst, the Pith, rising from the Flethy Substance in the crown of the Root, and forming a delicate and spongy lining.

ing. It does not fill the Stalk, for there is a large hollow in the center; across which stretch some few straggling Fibres.

FROM the surface of the Flethy Substance of the Root, within the circle made by the base of the Stalk, rise up, as in the Leaf-Stalk, the Conic Clusters of Vessels: they are very large, and conspicuous: there were six of these in the Leaf-Stalk; but in this Stem of the Flower they are twelve. Each is composed of a great number of Vessels, some white, and others yellowish; containing also a yellowish thick fluid. Nature has more to do in this Stem than the other; for a Flower as well as a Leaf are to arise from it.

As the Stalk advances higher, the hollow in the center becomes less; but these Vessels diminish very little, and they preserve their distinct number, only as that grows smaller they come close together.

AT the head of the Stalk, where it is not one fourth the bigness that it has at the base, these twelve Vessels crowd upon one another; for their diminution in diameter being very little, and that of the Stalk considerably great, they are here pressed so near, that they touch. See Fig. 5. Just below the origination of the Leaf is the smallest part of the whole Flowering Stalk, and there these clusters of Vessels are not only pressed much closer, but they unite into one uniform substance: and in this form they ascend to the Receptacle of the Flower.

IN tracing the course of the six substances of which the Stalk is formed, we find them in the following order.

THE outer Bark of the Root having terminated in the Scabbards at the base of the Stem, the six remaining substances only can form the Plant. Of these the inner Rind of the Root being now become the outer Coat of the Stalk, continues its course up to the Leaf, Fig. 1. c, where it terminates entirely. The Leaf is formed of this whole Coat expanded, and of a portion of the Blea, and some branches of the Conic Clusters; all uniting, and spreading outward, and dividing into six principal parts, with several subdivisions; instead of continuing their upright course, in form of a Stalk. Indeed this horizontal direction which the Rind, with the other substances, takes in the place of its first perpendicular one, is not so suddenly performed as may be imagined. At first the Rind terminates at this place, and spreads in breadth, and forms the Leaf: but that Leaf is continued in the same direction that the Rind was upon the Stalk, and makes the original covering of the Flower.

THIS Rind, tho' it appears a simple substance to the naked eye, is, indeed, composed of three parts, a central Vascular Substance, and two in-

vesting Membranes. Now tho' there be no Joint in this Stalk, as in the Anemone, and some others, where a new Footstalk rises to the Flower, yet we see in the part where this Rind leaves its office of a Coat, to assume the form of a Leaf, its three parts appear very distinctly: for the Vascular Substance between the two Coats enlarges to many times its original thickness, and constitutes a kind of swelling, by the great dilatation of the Vessels, but there is no Gland formed; there is no convolution, or interweaving of the Vessels, they swell at the termination of the Rind, in order to begin the Leaf, and nothing more.

THIS gives the naked eye a view of the real construction of the Rind of the Plant. For the swelling of the vascular part in its center separates the two Membranes to a distance, and when the Stalk is split in this part, one seems to rise at a small height above the other, with the Blea, in a thin coat, between. This appearance, however, deceives the eye, and is immediately set right by the Microscope. The whole Rind which forms this Leaf, terminates in it; and what we see is only the swelling of the Vascular Substance between its two Films, making a kind of bed for the portion of the Blea, and for the Conic Clusters, sent as Ribs into the divisions.

THIS being removed, we find the remaining Plant composed of only five substances, a Blea, the Vascular Series, a Fleishy Substance, the Conic Clusters, and a Pith; and crowned with a Flower, perfect, tho' without any Leaf under it; or any Stalk above the place of the insertion of the Leaf. The Rind terminating in the Leaf, only five of the essential parts remain for the construction of the Flower. The outer part, or Blea, is considerably thick and white. It reaches no higher than the Petals, and by degrees expands into them, and ends there. This Blea, like the Rind, has its outer and inner Coat; tho' they are extremely thin, and its central Vascular Substance much thicker: and in the same manner it forms the Petals. Each of these, tho' very thin, is composed of two Membranes and an intermediate Substance: these Membranes become yellow, where they rise loose to the air; and that is all their difference from the Blea, in its proper place and form.

THE Petals being all removed, we see the Fleishy Substance of the Stalk, which has here acquired a greener colour, running its strait course to the Filaments, in which it is to terminate. But over it, on the outside, there lies a yellowish Membrane; swelling, in form of cords, in certain places. As the Fleishy Substance of the Plant, like all the other parts, is composed of Vessels with Membranes enclosing them, it might appear that this was the

the outer Membrane of that part itself; but there is none correspondent to this within; and it is found separable from the Fleshy Substance, and is entire; and has its rise and termination altogether distinct.

It is a peculiar substance in the original construction of the Plant; the Vascular Series: it is thrown off by the Fleshy Substance at the crown of the Root; it accompanies that all along the Stalk; but it is so pressed between that and the Blea, that it is not to be seen distinctly otherwise than by this dissection; which shews all the parts in order.

WHEN we have taken off the Blea of the Stalk of this Plant, in the careful manner of the rest, we may next separate this yellowish Coat from the Fleshy Substance, without violence; and beginning at the base of the Stalk it will be drawn off freely, all its length to the very top: there it sticks, and the Stalk must be then laid in maceration in warm water, for some hours: for if any violence be used, we break the parts, instead of separating the whole.

AFTER this repeated maceration we may re-assume the business. The yellow Coat will come off clear and entire: the Filaments remain in their full number; but together with this Coat come off certain oblong tubular bodies, resembling small gaping Flowers. These are the Nectaria of the Plant, and are altogether like those of Hellebore, to which Genus it belongs.

WE see here is a peculiar organ in the Plant; and we are no longer to wonder that there was a particular Coat to form it.

WHEN we have got these off, with the Coat which terminates in them, we see what necessity there was of care in separating that part gently from the rest of the Plant, in order to preserve them with it; for they adhere to it by so very minute a base, that now they are separated from the rest, they drop off with a touch.

THERE are five of these peculiar Bodies in the Flower; and the rising lines like cords in the yellow Coat, from whose extremity they spring, are the continuations of these five Bodies down to the Root: the membranous matter between only serving to connect them together and hold them in their places.

EACH of these Nectaria is composed of two parts, a Body and a Footstalk. See Fig. 6, Letters a and b. The Footstalk is flat and greenish; the Body is fleshy, and of the colour of bees-wax. It is hollowed like a spoon; split at the top into two parts, and covered half way with a Lip. It is thick and soft, full of this yellow tough Juice; and is composed of the whole body of the Coat whence it rises, the two Rinds covering the Vascular Substance between.

THE Flower properly consists of TWO SERIES of Petals, three in each; the three outer are LARGER, the three inner much less; and they are all OBLONG. Immediately within these rise the tubular Bodies just named. They have no connection with the Petals: they rise between them; and they seem to serve a double purpose, first to assist in defending the rising Antheræ from injuries, where there are gaps between the Petals; and afterwards to secrete that yellow Juice just named, and deliver it to the Filaments. They communicate with these by large Vessels at the base. This yellow Juice is wax; and being indissoluble in water, it very happily defends the particle of the Flethy Substance lodged in each grain of Farina for a new Plant.

NEXT within these Nectaria rise the Antheræ. They are EIGHTEEN in number; and each of the Nectaria communicates with three of them. Within these appear the Rudiments of FOUR Seed-Vessels.

THIS is the structure of the Flower; very different from the general character of the ACONITES. We have seen how the Flesh is continued up into the Filaments: these are now the outermost substance of the Flower; and the outer Coat of the Stalk is that Flethy Substance. A slip of this, being carefully raised from the Conic Clusters and Pith, brings away three series of Antheræ with it, in which it terminates: its whole substance dividing into them at the head, where there is a very small Receptacle formed of the white spongy parts of the Conic Clusters.

WE know the Flethy Substance consists of a vascular Matter between two Coats: and so do the Filaments. Each is a tube formed of these three substances; and each supports an Anthera, which is large, yellow, and appears double. Fig. 6, c.

THE Footstalks of these Antheræ are the Filaments. These are not brittle as those of the Nectaria; but so tough, that it is not easy to separate them without violence. Being pulled downward, they take off a small piece of the Flethy Substance with them. They are very elegantly formed.

THE Footstalk, or Filament, at its base is rounded; but it grows broader and flatter toward the top. The Anthera, in many Plants, is fixed to the Filament by an extream small neck, but here it is the largest part, which sustains it. In those the Anthera seems a distinct body fastened on the Filament; in this it is a plain continuation of the body of the Filament itself, into two swellings: we see that distinctly here, which is really the case in all.

THE ZERUMBETH, and many other of the Asiatick monandrous Plants, have a divided Anthera: and some have thought LINNÆUS did amiss to

class them in his first tribe; calling the divided Anthera two. But that great Author judged much better than these Criticks: he calls the seeming two Antheræ, the two parts of one divided Anthera, connected by a Membrane: and Nature, in other instances, avows the truth of it.

IN the AMARYLLIS each Anthera distinctly consists of two tubes, within one common Membrane, pressed close together. In the AMOMUM ZERUMBET, the Anthera is also composed of two bladders of Farina; and they are not pressed together, but lodged separate at a distance, within one common Membrane. It is the same in this Plant: Each Filament is one substance, wrapt in one Membrane, and yet the two Bladders of the Anthera are so distant, that they appear two Antheræ to the Microscope.

THEIR true formation is this. A portion of the Flefhy Substance of the Stalk separates from the rest, and runs up in form of a Filament. Its own outer Membrane covers it; and within is a vascular substance, and an inner Membrane. The inner Membrane does not go up regularly as the outer, and line the simple tube it forms: but splitting lengthwise, it rolls each way inward, and by this means the Flefhy Substance being connected to it, and rolling with it, there are formed two lesser tubes within the original one. See Fig. 6, d. Each of these has a smooth Membrane to line it, which was the inner lining of the original body; and its outer surface is the naked vascular part of the Flefhy Substance; naked as to the individual tube; but safe from injuries, being covered in both with the outer Membrane.

THESE Tubes diverge as they rise; and at the head each forms a kidney-shaped spongy body, of a yellow colour. These are still contained within the outer Membrane, which covers the Filament and Antheræ entire; and there appears a part of it between them.

THUS does the Flefhy Substance of the Stalk terminate in many oval yellow bags. These are composed of its Vascular Substance; and from these, particles rise in form of globules of Farina, and separate continually as they grow dry in ripening. Each particle takes with it a covering of the inner Membrane, which lines the bags equally with the tubes; and into this is thrown a little of the waxy matter, secreted for that purpose in the Nectaria, and conveyed, by communicating Vessels, up the tubes. These very Vessels are seen distinctly before a good Microscope, at their entrance into the Filament, and up the whole length of it. They enter near the base, two into each Filament; and they run up like yellowish cords along the surface of the Filament, just under the outer Membrane.

EACH

EACH particle of the Fleſhy Subſtance of the Plant, thus ſeparated in the body of the Anthera, cloathed with a Skin from its inner Membrane, and covered with a little of the waxy Juice, is a globule of Farina. Every particle of the Fleſhy Subſtance of a Plant is capable of growth into a whole Plant of the ſame kind; for its ſeveral Coats are formed from its own Juices, and the very organs of a Flower are its natural terminations. Therefore this particle, in a globule of Farina, is capable of growth into an entire Plant: it is tender, but it is well defended: for even in this globule it is ſurrounded with wax, and covered with a Skin; and is thence delivered to the Seed, where it is ſafe till ſown.

HAVING thus cleared away all the Coats of the WINTER ACONITE, there remains a divided column of Pith, from the ſummit of which grow four Seed-Veſſels; but ſtill it is not the abſolute naked Pith which riſes to the very ſummit of this column. Where the Leaf, the Petals, the Nectaria, and laſtly the Filaments, have been torn off from it, its naked white and ſpongy ſubſtance makes the ſurface; but theſe have not reached to the abſolute ſummit of the column. There is a ſmall conic eminence, the head of the Receptacle, above the place where the Filaments were torn off, and juſt below the baſes of the Seed-Veſſels: this above has a kind of covering: it is a yellowiſh green ſubſtance, and ſhews itſelf even to a moderate magnifier, to be more than a mere Membrane. It is, indeed, a part of the Conic Cluſters of Veſſels which riſe within the Fleſhy Subſtance of the Plant. That original part terminates in the Filaments: nor is there any need it ſhould go farther: the parts which ſeparating from thoſe Filaments, are each of them perfectly diſtinct, and one as well as another equally capable of a new Vegetation. When this Fleſhy Subſtance has terminated there in that manner, the Conic Cluſters of Veſſels preſſed cloſe together, continue their courſe a little higher, and form this part, which is the very ſummit of the Stalk. This appears an arch in a perpendicular ſection of the Plant; but when cut off tranſverſely near the ſummit, it forms a kind of dome, of a pale green ſubſtance, filled with the white Pith, and pierced with four diſtinct, and not very minute, holes.

THRO' each of theſe riſes a column of the Pith; which a proceſs of the yellowiſh Coat of the Crown covers, and theſe make the four greeniſh Seed-Veſſels. The Conic Cluſters are thus continued, in a ſmall portion, to the very ſummit of the growth, and principally form the Valves of the Seed-Veſſels, which the thin Membrane, covering the Pith, lines.

THE Pith itſelf here, in its extreme growth, breaking into pieces, forms a kind of white filmy Bladders, with a ſpongy ſubſtance in them; and into theſe

these are received the little particles of the Fleſhy Subſtance lodged in the globules of Farina: they are then perfect Seeds, and ready to grow.

THE way by which theſe covered morſels of the Fleſhy Subſtance get into the Seed, is obvious. The tops of the Seed-Veſſels riſe in a kind of Stigmata, or dewy heads, with open tubes, covered with a ſhining moiſture: on theſe the globules of Farina fall; and burſting there, the ſeparated particle, with its wax, makes its way down the future, to the open baſe of the Seeds; in which being lodged, it is called the Plantula Seminalis.

THE Figures in Plate XI. ſhew the principal of theſe parts, with their ſeveral terminations, diſtinctly, as they appear to the naked eye entire, divided and ſeparated one from another. Fig. 1, expreſſes the entire Plant in its natural ſize, with all its parts. At Fig. 2, is repreſented the ſame Plant ſplit down from the Flower thro' the Root, to ſhew the diſpoſition of the Fleſh in the Root, and the origination of the Stalk. Fig. 3, ſhews a ſection of the Footſtalk of a Leaf, with its ſix Conic Cluſters of Veſſels. Fig. 4, a ſection of the Flowering-ſtalk near the ground, where they are twelve, and are diſtinct. At Fig. 5, is repreſented a ſection of the neck of the Stalk near the Flower, where they are preſſed cloſe together by the ſmallneſs of the Stalk. Fig. 6, expreſſes a Filament and Nectarium, enlarged by the Microſcope. And the remaining Figures ſhew the ſeveral Coats and conſtituent ſubſtances, as they come off entire, by means of a long maceration, and careful management.

FIGURE 7, ſhews the outer Rind of the Root; which, being taken off entire, terminates in the Films, defending the baſes of the Stalks, and is not continued at all into them, or upon them. The inner Rind is repreſented at Fig. 8. This forms the Leaf on which the Flower reſts; and terminates in it. The next Coat or Blea is repreſented at Fig. 9, forming the Petals of the Flower; and terminating in them. At Figure 10, is ſhewn the Vascular Series alone and entire, terminating in the Nectaria, and forming them entirely. At Figure 11 is ſhewn the courſe of the Fleſhy Subſtance of the Plant, terminating in the Filaments. And at Fig. 12, the Pith, in three diſjointed pieces; one being the Pith of the Root, a ſecond of the Stalk, and the third of the Seed-Veſſels. The Conic Cluſters are diſpoſed in this Plant exactly as in the Hellebore; and, therefore, as they could not be repreſented diſtinctly in a Figure of this ſize, it is better to refer back to that Plate.

HAVING thus ſeen diſtinctly the ſtructure of the Plant, we ſhall be able to trace the courſe of its Juices thro' thoſe ſeveral parts we have examined; and we ſhall find here a much more complex body than the Colchi-

cum, supported by a single system of Circulation in the Root, with a small help from the Conic Clusters.

THE general course of Nature in the nourishment of Plants, is what we have seen already in the COLCHICUM. The outer Bark receives from the earth, evaporates, and again absorbs from the air, a great deal of watery matter; of this a small portion is secreted, and delivered to the Vessels of the inner Rind: they receive also their portion of watery nourishment; and make their secretions, which, with those of the outer Bark, they deliver to the Blea. In the Blea a new secretion is made, and a third concoction is given to the first of the other Juices; and this elaborated fluid being now fit for the nourishment of the Plant, is conveyed to the Flesh. There it circulates; and thence begins the growth of all the parts. The Vascular Series is formed on the surface, and the Conic Clusters; and the Pith, within; and processes of the Flesh accompanied by these its natural productions, rise to form the Stalk, and terminate in Flowers.

ALL this depends upon the force of a Circulation in the Flethy Substance of the Shell or Coat, g, Fig. 2, Plate XI. The moisture that is received by the Root, and by the Leaves, when its nutritive particles are secreted, is, in part, evaporated during the heat of the day; and more is received, replete with the same kind of particles, to supply its place. This is done continually; and, therefore, there is a continual addition to the Juices of the Flesh. This redundancy forces up those Processes which form the other parts of the Plant; and all the time a secondary Circulation is carried on by the Vessels of the Conic Clusters. These make the Ribs of the Leaves, and the Receptacle of the Flower; therefore they all reach every where the extremities of the Plant: they all return from thence to the base of the part whereto they belong; and there they have a delicate communication with the Flesh of the Root.

Thus, in the Plant now under examination, the single circulatory system is in the Flesh of the Root; but the Radical Leaves and Fibres of the Root assisting, the full nourished Flesh of the Root sends up a process which forms the Stalk: this, when it is raised as high as the force of that single circulatory system can carry it, stops its growth, and the several parts then separating, a Flower is formed, in which are produced the Rudiments of many new Plants. Every essential part is nourished by the coat of Flesh in the Root; and into every part run some of the Vessels of the Conic Clusters, which take their origin from it.

THAT the growth and height of the Plant depend upon the quantity and disposition of the Flesh, will appear in the comparison of the heights of several Plants with the quantity and place of the Flesh. Thus we see, that



Winter Aconite.

For the year ending 31st March 1900

By the Hon. the Secretary of State for the Colonies

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that in the COLCHICUM, where the whole head of the Root is extremely thin, and consequently the Flesh of it in very small quantity, all that is raised from it is a Flower without a Stalk. This we accounted the first and lowest stage of growth. In this WINTER ACONITE the Root is thick, and the quantity of Flesh very considerable, and consequently a Leaf as well as a Flower are formed, and a Stalk raised three or four inches high, to support them. This is also the case in the Hellebore: and from these, and a number of other observations, it seems to me, that three or four inches, or thereabouts, is the height to which a single system of Circulation naturally carries up a Stalk.

FROM this we shall advance to the consideration of a Vegetable Body yet something more complex, selecting the ANEMONE; whose Stalk is considerably taller, tho' it have no more Leaves than this; but whose advance in height requires a second system of Circulation.

THE course of these experiments on the WINTER ACONITE, shewed me accidentally, that it is capable of yielding, with Steel, a crimson Dye, perhaps equal to that from Cochineal.

C H A P. XXXVII.

Of the A N E M O N E.

IT is by the most gradual advances we must expect to arrive at a knowledge of Nature; for all her changes are made by such advances only: there is no great gap in her everlasting chain; nor can we ever rightly follow her course, unless we mark all the gradations.

FROM the stalkless COLCHICUM we have continued our research up to the construction of the WINTER ACONITE, whose low Stem one circulatory system is able to nourish and support: but more of these are necessary to taller Plants; and in the ANEMONE we shall find distinctly two; the first seated as in the preceding Plant, in the body of the Root; the second in the lower half of the Stalk.

THE Flesh in the Root of the ANEMONE fed by its Fibres, and its Radical Leaves, sends up a thick Process of itself, in form of a tubular Stalk, which gets in the free air all its coverings. This rises by the strength of the Circulation in the Root, to the height of four inches, or something more, above the ground; but as the Stalk is to be carried up a second stage, there is a new system of Circulation formed.

As the Flesh of the Root forced up this lower part of the Stalk, the Flesh of this lower part forces up this upper half. A circulatory system is necessary for this; and Nature has given one: for the Flesh of the lower part of the Stalk makes an arch, and returns upon itself, at the place where the Leaf grows; and a Circulation is carried on in this part as evidently as in the Root; from whose force arises the second Joint of the Stalk, supporting the Flower.

I PLANTED AN ANEMONE Root so late in the summer, that it should not flower till late in winter. December the 17th I took it up in full bloom; and found, on cleaning the Root, that since the planting it had, beside the Flower, produced some NEW PARTS. The Root, when put into the ground, consisted of a tuberose head, and from this grew five processes, of different lengths, with UNEVEN ENDS: the whole was dry, hard, and of a dusky brown; only at the crown appeared a thick part paler than the rest: this was the principal Bud.

WHEN taken up, the five Processes grown much longer; and there were shot out from the head the Rudiments of two others, in form of Buds. The whole Root was of a pale brown; and four of the processes yet paler; but the fifth, which lay lowest, and was a continuation of the head of the Root, was of the same brown with that part.

FROM the head of the Root, and from this undermost Process, grew many loose Fibres; from the others none. This part, therefore, is the only one in an ANEMONE that is properly to be called a Root. It is in this state of the Plant the natural body of the Root, altho' it has been one of the common Processes originally. The others are lengthened Buds; and nothing more. They are thus formed.

WHEN AN ANEMONE Root is taken out of the ground, there is on its Crown a Bud, which contains the Rudiment of the next year's Stalk and Flower. When this Root is planted, Nature not only sends up the Stalk from the Bud, to produce Flowers and Seeds, but, careful of accidents, she sends out also other Buds, which are to propagate and increase the Plant from the Root. These appear upon the head of the old Root; and they are Shoots from the Flesh. Which from themselves form a Pith, and pushing out the Coats of the Root, and making their way to the surface, there appear in several conic bodies, covered with many filmy scales; these scales are formed of the three outer coats of the body of the Root, which having been all pushed out by this Shoot from the Flesh, throw off imperfect Films from their stretched parts, which serve to defend the tender Plant or Embryo contained in the Shoot.

WHILE

WHILE the Plant flowers, these are filled with nourishment, and they grow, and thrust out farther from the Root: they become lengthened to an inch or more; and the lowest Films being always left upon the Process, that whole part has a scaly surface. See Plate XII. Fig. 2, *a a a*.

WHEN the Process has attained this length, it is in a state of growth for a new Plant. It may be broken off from the original Root, and put into the ground. The wound being only at the end of the body, is of no consequence; the Bud which was the original of the whole remains unhurt at the other end, and forms a Crown, Fig. 2. *b*; from which a new Plant rises.

GARDINERS take these Processes, for parts of the Root; but they should distinguish better. No Fibres grow from them while they adhere to the Root; nor does their extremity shoot in length, as the ends of Roots do; but keeps its original form; while the scales which cover it, give it a ragged appearance.

WHEN one of these Processes, which we see are only lengthened Buds, is broken off from the old Root, and planted in the ground, it takes a new condition. While it remained fixed to the body of the Root, it had its nourishment thence, and therefore needed not to shoot out Fibres: but when separated, and planted, the lengthened part by which it was joined to the Root, assumes the condition of the bodies of other Roots, and sends out Fibres to draw nourishment for the support of the embryo Plant, which is now ready to shoot from its Crown.

THE base of the Bud, Fig. 2, *c*, where it originally rose from the surface of the old Plant, swells first, and forms a head of a Root, just such as that from whence it sprung; the whole exterior part of the Bud then lengthens and enlarges; and Fibres are shot out from the lengthened part of the Process. Presently the scales of the Bud, separated by its increase in length, open, and there burst from them Shoots; but these are only Rudiments of Radical Leaves, *d*. The Crown itself remains unopened, and the embryo Plant for flowering does not yet grow. There requires the assistance of the Leaves for that effort.

THE second year this Crown opens, and the Flowerstalk rises: and at the same time new Buds burst forth upon the head of the Root near the Crown; such as in the old Root gave origin to this; and these lengthening into so many Processes, are ready afterwards to be separated from the Root, and grow.

THIS is the propagation of the ANEMONE by increase of Root: and three years are necessary for the full procedure. The Bud which is formed

ed this Autumn, 1758, will be a long Process in 1759, fit to be separated from the Root; in the year 1760, this will send up Leaves, and in 1761 it will flower; and new Buds will then be formed from it.

HERE let us rest, and wonder! the proceeding of Nature, thus explained, is simple and familiar; but how delicate it is; and how long time is required for it! The ANEMONE which I have now before me, December 1758, was formed in the Autumn of 1755; and has been all this time nursed under the bosom of the earth, and under covert of innumerable scales. It is a piece of the original Root, and has been all those years forming: first nourished by the Root, and then by Fibres of its own. This we find is the constant course of Nature, by taking up the Root at various seasons, in succession. And certainly it is worth the while to enquire, What is the internal structure of the increasing Bud from its first appearance; how the young Plant is formed; and by what stages it attains perfection.

THE Rudiment of a new Bud is always formed at the time when a Stalk shoots from the Root for flowering: the same force of Nature effects both these purposes; therefore the first enquiry after the origin of a Bud, must be in a Root just sending up its flowering Stalk: and to avoid confusion of parts, it is best to chuse a new Root, just pushing for its first Flower.

DISSECTING this Root lengthwise, we find it is composed of the usual seven parts; 1. a brown outer Bark; 2. a whitish spongy inner Rind; 3. a white Blea; 4. a Vascular Series; 5. a Flethy Substance, which is resinous and yellow; 6. a series of Conic Clusters of Vessels; and 7. a vast Pith. This is the construction of the body of the Root. The Head has the same composition exactly; but the Pith bears more than double the proportion there to any of the other parts. This exactly receiving water as a sponge, causes the swelling; and from the Fleth covering it there, rise the Shoots. The interior part of this Head is still terminated by its original and proper Bud; and from this rise the Stalk and Leaves; the Stalk from the end, and the Leaves on each side.

IT was in the year 1756 I began these enquiries; and I selected for the purpose a number of young Roots, then ready for their first bloom. Upon one of these I began the experiments; and the rest were planted in the usual manner the succeeding years, to mark the formation and progress of the Bud, which afterwards was to be a compleat Root.

A FLOWERING Root of the kind just mentioned, being split lengthwise, we see the whole substance of it is contracted, at the upper extremity, into a kind of neck; and thence arises the Stalk, Fig. 2, *e*.

THE

THE Neck, or part between the Root and Stalk, has the form of a small ring; and seems to divide them one from the other. The Stalk, on a slight view, might seem rather fixed upon the Root than rising from it: but the Microscope shews the wonderful mechanism, and it is this.

THE outer Bark, the spongy inner Rind, and the Blea, all run up in a continued line from the Root: but the Flesh, at the union of the Root and Stalk, forms an arch: from which rises a process or part of the surface, forming the Flesh of the Stalk; which soon gets those coverings as it rises.

THUS is the Stalk continued from the Root, and is truly a lengthened Process of that part, extended upwards. When the force of the Root ceases, at a certain appointed height, being the utmost the circulatory system of the Root can effect, a second system is formed; and when a new Stalk is forced up from this, as the first was from the Root, and has reached its utmost height, the parts open into a Flower. The three outer Petals, *f*, are formed of the exterior Rind of the Stalk; the inner Bark forms the three innermost Petals, *g*, and there terminates: the Vascular Series terminates in a thick Ring, *h*: the Fleishy Substance forms the Anthera, *i*: the Conic Clusters make a Receptacle, *k*; and the central Pith forms the Seeds. So ends the Stalk; and these Seeds ripening, produce new Plants: only continuing to grow.

THE essential part to a Plant is in this, as in all others, the Fleishy Substance of the Stalk: and a piece of this is lodged in every globule of Farina; which being sheltered from danger in the Seed, afterwards grows.

OF this we have already treated at large: it is the Root we are properly examining here. While the principal part, or main body, of this Root, is thus continued upward in a Stalk for flowering, the Fleishy Substance, furnished with abundant nourishment for the growth of the Stem, swells out also a little on one side, near the Joint, where the Root ends and the Stalk begins. The time of this swelling is just when the Flowerstalk is rising; and its first appearance is a YELLOWISH Knob or LUMP, visible only by the Microscope.

THE origin of this is just such a PARTICLE as that which is to be afterwards lodged in each grain of the Farina, and thence delivered to the Seed; and having the same vegetative power, or Principle of Life with that, it grows in the same manner. It is already in the ground; it is as securely bedded in the body of the Root, as the other can be in the Seed; and having an immediate supply of nourishment from the very Fibres of the Plant, it directly grows.

NATURE is wonderfully uniform in her course; and whenever we think otherwise, it is because we do not understand her operations. It was not known, till from some former observations I was so happy to make, that the Rudiment of the future Plant was in the globule of Farina; and that it was only a particle of the Flešhy Substance of the Stalk: but now that is demonstrated, we see that the little lump, first formed for the production of a Bud, is the very same thing; and we have the satisfaction to find, that in each of these states, distinct and unlike as they seem, the same course of time is required to bring them to maturity. When the ripened Seed is sown, the third year shews the Flower: and in the same manner three years serve to perfect this Radical Lump into a Flowering Plant.

IF the Seed be kept safe out of the ground a year or two, it will yet grow, when sown; and if the Bud formed from the Radical Particle be at its due growth, separated from the old Root, it will, in the same manner, bear to be kept a long time out of the earth; and yet will grow when planted. The case is just the same. The Seed and the Root serve equally as coverings for this living Particle of the Flešhy Substance; and so long as they are kept from mouldiness, fermentation, and decay, that Particle is always ready to grow.

THE new-formed Lump on the side of the Root is in the state of the Rudiment in the Farina; and powerful Microscopes will discover in this, as in the Seed, a cluster of Fibres toward the top, which are arranging themselves for the Formation of the Plant to come. Soon afterwards their form becomes more distinctly visible.

THE new-formed Lump pushes outward, and soon shoots inward a Pith, its proper lining. The first formed Particle cannot do otherwise; for it is a piece of that substance of the Root from which the Pith grows. In a few weeks this Lump, which was at first only a yellowish spot, becomes a LENGTHENED STREAK; making its way in a direction a little OBLIQUE, and pointing upwards, toward the outside of the Root.

SOON after it forces out the BLEA of the Root, its spungy inner Rind, and its outer Bark; and is thrust, together with them, to the level of the surface, and presently after beyond it. It is not there naked; for the several outer Coats of the Root which it has carried out with it, send forth, from their surfaces, a multitude of filmy substances, which encompass it as scales, forming a proper Bud; as regular as that upon the most common Tree.

AT this period, when the head of the Bud is advanced toward the free earth, the crown of it contains that cluster of Fibres first seen, something
more

more advanced ; but still so unfashioned, that none but those who know what they were to expect, would find there the least resemblance of the succeeding Plant. This may be called, for distinction, the Rudiment in its second stage.

FROM this time these several parts of the succeeding Plant grow something more distinct, as the Bud increases ; till at the end of that summer, when the Bud is full formed, and the Roots are ready to be taken up, the complex body has at its top something like the Anemone Flower. This may be called its third stage.

WHEN the Root, with this Bud upon it has been planted again, and has remained its flowering season in the ground, on taking it up, the Bud is found lengthened into a Radical Process ; and the Crown of it being split open, there is seen the Rudiment of the succeeding Plant, in its fourth stage. Its place is near the Crown ; and somewhat on one side : and to the unassisted eye, it appears but as a small dusky spot : but the power of the Microscope shews now the form of the whole succeeding Flower, except the Petals.

THIS want of the most shewy part, would mislead the common eye ; but those accustomed to natural researches, know the most essential are always first formed, and those of less importance afterwards. We know the Rudiments of Seed are the most essential in this case ; and therefore they are to be first expected visible : we see them accordingly : not in their proper form of Seeds, for they constitute the inner Petals in this Double ANEMONE ; and they have, even thus early, a tendency to that shape. The appearance now is an oval body, surrounded and covered with Films. The Stalk is all this time invisible, and even the very Rudiments of the outer Petals.

WHEN this Process has stood its due season, it will shoot up a Flowering Stalk ; whether it be separated from the Root, or planted again with it. If we take up such a Root when it has been a month in the ground, we find the young Flower in the center much more distinct : the six outer Petals are plainly formed, and they soon increase in size. This may be called the fifth stage of the young Plant : and after this the process to a perfect form is much more rapid.

AFTER one season more this new-formed Plant is to shew itself above the ground. Taking up the Root soon after planting at that period, we find the young Flower much more distinct : but covered by long and pointed purple scales, it now resembles a Rose in its Bud, with the jagged end of the Cup about it : and one would be apt to think the ANEMONE had

originally a Cup like that Flower, tho' it never appeared above ground. This is the sixth stage of the Rudiment.

THE seventh is to be seen somewhat later in the same season; and that explains all. The Process being now become an absolute Root, and the young Plant ready to rise from it, we see the Flower yet more perfect; and find those purple Films which seemed a Cup, are really the Rudiments of that peculiar Leaf which is placed about the middle of the Stalk in the full-grown ANEMONE: there appears also now, and never before, the Rudiment of a Stalk, uniting the Root and the young Flower. This is the last stage of the embryo Plant: what follows is done above ground, and open to all eyes.

THE Bud pierces the surface of the earth, supported by its short Stalk, and with its top downwards. The end where it is joined to the Stem is defended by the Leaf which is to expand upon the middle of the Stalk; and this makes it able to resist injuries. Its form is that of a Swan's Neck; and the extremities of that particular Leaf make a kind of Fringe to the bent part, Fig. 1, *a*.

From this time it grows fast: the Stalk lengthens, the Head swells, and from the bigness of a small Pea is soon equal to a large Bean, *b*. At four inches height of the Stalk, the Leaf which has hitherto been closed about it opens; and the Stalk losing its bend at the top, becomes nearly erect, Fig. 1, *c*.

THE Bud of a Flower is now large, but green; and fits close upon the bosom of that Leaf; as the Flower of the YELLOW HELLEBORE, which we call WINTER ACONITE; before described. From this time the progress to perfection is swift: a Stalk shoots up from this Leaf; that is, the Stem of the Plant, which has hitherto been terminated there, rises by a new growth from it, as from another Root.

THE Flower is then supported at two Inches above the Leaf which hitherto defended it, performing the office of a Cup: and the Petals, which were hitherto green, become red, the Plant is now in its perfection, Fig. 1, *d*. The original six Petals of which the Single ANEMONE was composed, have sent up from the same base a number of other large Petals like themselves; the pale Filaments originally crowned with yellow, are converted into a kind of crimson clubs: their form, in some degree, remaining, tho' their colour and qualities are lost. These make a crimson fringe just within the base of the Flower, *e*; and what in the Single or natural ANEMONE were Rudiments of Seeds, swell here into narrow, coloured Petals; and constitute the great doubleness, *f*.

THIS

THIS is the Fact: but it will be useful also to explain the manner. To understand this justly, we must begin at that spot in the Plant where resided the original Principle of Life; and trace it thence, downward to the extremest Fibre, and upward to the Flower. This strict enquiry carries us back either to the Seed, or first Bud from the original Root: it is equal which we take; for the Principle of Life is the same in both; and its equal progress in either, from that first simple Rudiment to perfection, being the same, they mutually illustrate one another.

THE great Axiom is, that the Fleishy Substance of the Stalk is the essential part of the Plant. In this the power of Vegetation resides; it resides in every part of this; and in no other part of the Plant.

ANY Particle of this which can be preserved from putrefaction in the earth, will grow; and no other part can grow without this. This being planted, will produce all the others; but all the other parts, without this, perish: they cannot produce this; and there is no Vegetation without it. The essential part of the Flower is formed of this, and it is a portion of this lodged in the Seed that grows. The experiments lately made, under my direction, by Mr. BARNES, upon the principles of AGRICOLA, shew this. Every part of a Plant which contains but a particle of the Fleishy Substance, will grow into a perfect one, if kept from putrefaction.

ON this fundamental truth depends all.

A PARTICLE of this Fleishy Substance of the ANEMONE Stalk, lodged in a Seed, or in the center of a Bud, is the Rudiment from which a new Plant of the ANEMONE is to grow. This is at first a speck too small for the sight, unless assisted by the most powerful Microscopes: It is defended by the spongy substance of the Seed, or by the substance of the Root, which grows round about it in the Bud: But this lives; this only lives; and it is the Principle and Seat of Life in the succeeding Plant.

WHETHER a Seed, or a lengthened Bud of the ANEMONE, called a Parted Root, be set, it is from this spot the succeeding Plant rises. It is lodged by the Gardiner's hand, at some small depth under the earth; and there it begins to grow. Roots are sent downward, and a Stalk is shot upwards, each from this one point. This remains always in the succeeding growth; and is the Seat of Life in the Plant. All the rest grow from it: What we call the Stalk, is only a continuation of a part of this upward; and what we call the Root, is, in the same manner, a continuation of it downward: both are extensions only of this point: being of its nature, they contain the power of Vegetative Life, as the original piece does; and being planted, as that was, any piece of them is as ready to grow. This I

have found : for pieces of the Stalk, or of the Root of an ANEMONE, ever so small, if covered in the wounded part with Cement, will grow, and become perfect Plants ; as pieces of the Polype will become perfect Animals.

WE are now to trace the progress of this original point, or Particle of the Fleshy Substance, into a perfect Plant.

WE have shewn how it is formed by growth from the head of the Root, and how it gathers strength in three seasons, while yet lodged in secret in the heart of the Bud. At the end of that time it is planted out.

THIS separation constitutes the Process a distinct Plant : till this time it had been a part of the old one. We have seen how this acquires its growth, and we will now follow the Seed.

IN this, as in the Bud, is lodged an original particle of the Fleshy Substance of the Stalk of the parent Plant. It is put into the ground, and after some days it separates from the Husk ; and we see the original Particle naked ; it is small, dusky, moist, spongy, and scaly. A few slight Fibres first shoot downwards, and a Film soon after covers the first Particle, from whence these spring. This, by degrees, thickens, and becomes the Blea ; or that part which in the perfect Plant is to be the third Coat, counting from the surface.

THE tender Fibres which were first shot from the naked Particle, and were themselves also naked, get at the same time also this covering of Blea ; and in the second stage of growth, they consist of a solid fleshy matter, and one Coat. They are continuations of the first Particle itself, and are the same in substance. Their first state was nakedness ; and in this the whole would have rotted and decayed. The substance of the Seed had defended the Particle before, and now it is robbed of that, provident Nature is giving it a new defence, formed by the secretion of its own Juices ; as the shell of a Snail, or the coverings of other tender Animals are formed.

THE original Particle is covered on the surface with the open ends of those tubular parts which, in a kind of chain, form its substance. The first Juices they secrete, cover the naked body with a slime, which soon condenses, and becomes this Blea, coating the whole down to the extremities of the Fibres. In the first stage the Rudiment was a shapeless Particle. In this second stage there begins to appear a body of a Root ; it is a little lengthened from one end, and gives the Rudiment even already the form of a Process.

IT has been supposed, the Pith, or central substance of a Plant, contained the Vegetative Power : but all this time the new Plant is growing, and no Pith is yet formed.

THE Fibres being covered act more vigorously ; and soon the Particle, which we may now consider as the body of the Root, swells : the increase is inward : and in the third stage, which a few days bring on, the tubular openings within, send forth a Juice, as those on the surface first did ; and this swelling and distending the Particle, forms, by degrees, a Pith. This is equally done in the body of the Root, (for so we may now call the original Particle) and in those Processes of it which make the Fibres : for being two parts only of one substance, the same change happens at once in both. Thus we have the formation of those parts which are to be conspicuous in the future Plant. These stages of growth are arbitrary ; and the progression is very swift from one of them to the other. But they are determinate, and distinct : and therefore highly useful.

LET us remember that this original Particle which is to grow into a new Plant, was a part of the Flešhy Substance of the parent Plant, terminating in a globule of the Farina ; there it was covered with a waxy matter ; and thus covered it was delivered into the shell, which having received it, became a Seed.

ALL these things are extraneous to it : they serve for its preservation ; and nothing more. We have seen the Seed planted ; we have seen it burst ; we have seen the original Particle delivered naked from it, after having first received the beginning of vegetative growth within it ; and we are now to follow it into the form of an entire Plant. Its original body swelled, and set to growing, with a few naked Fibres produced from it, was the first plain stage : yet this naked, and almost shapeless morsel, was a perfect Vegetable, capable of growth, and of producing all the other parts. In the second stage, we see a white Coat formed to the dusky spot ; and in the third, a Pith formed within it. Three substances are already constituted : the whole Plant consists of only four more, and they soon follow.

THE Blea is formed of the hardened Juice thrown from the ends of Vessels of the Flešhy Substance ; other smaller Vessels of the same substance, whose ends were not open, run into this Blea ; and take their course along it. These unite the Blea to the Flešh, and one system of Vessels serves them, and runs thro' them : and between these is formed, from the Flešh, the Vascular Series.

THE Blea has its Vessels also open upon its surface, and a Juice is discharged from them, just as was originally from the Flešh ; only in less quantity. This covers the new-formed Body and Fibres all over ; and condensing afterwards it forms a new Coat upon the Blea. This is the inner Rind of the entire Plant. Vessels are continued out of the Blea into this,

this, and run their course up the whole height that it is carried in the succeeding growth of the Plant. This is the fourth stage of the Seedling Body: and it consists now of five substances; or more properly, the original Particle has formed three Coats outward, and a kind of marrow inward.

Two more parts are to be produced, and then all will be perfect: these are the outer Rind, and the Conic Clusters of Vessels. The Vessels which open upon the surface now are few, but they discharge some fluid: this condenses as the former had done, and makes another Coat of the Plant, a fourth cover to the original Particle: it is the outer Bark. The Conic Clusters also rise between the Flesh and Pith; and all is now perfect.

THUS we see of what parts a perfect Vegetable consists, and how those parts are formed. It has been thought all arose of the Pith: but that led to many errors. A section of one of these young Roots of an ANEMONE will shew the system here established plainly: and tho' it differs a little in the order of production, it is the same in all other respects as in the former instances.

FIBRES have their Pith as well as the body of the Root: but the Pith of the Fibres is not a continuation of the Pith in the body of the Root; nor has any the least connection with it. The Fleishy Substance, which was the original part, is now continued entire round the Pith in the body of the Root; and separates the Fibre wholly from it. That Fibre is a continuation of the original Fleishy Substance, and has the same Coats continued; but the Pith itself is secreted distinctly from the body of the Root, and from the Fibre; and having not been formed when the Fibre was produced, it is not, nor can be continued from it into the Root.

THUS is formed, in the Seedling ANEMONE, an absolute and perfect Vegetable, before there is the least growth of a Stalk: and if it be so in all Plants, as I have found it to be in many, they talked wildly who have said they saw the perfect future Herb in the Seed. The Plant is to be nourished from the Root; and Nature has a great deal to do in the Root before it comes to that condition.

ALL this time a Root only is formed; with some faint approach toward Radical Leaves; and all the parts, even of the Root, are very tender, tho' the Microscope can shew them thus distinctly. The growth has all been from one point; and that keeps its place at the anterior extremity of the Root: there the Microscope shews the minute and dusky Rudiment of a Flower, inclosed in the Leaf which is to serve it hereafter, as a cup; and this is all. The Stalk is accidental, and a trifle; it has no place in the Rudiment;

Rudiment ; but is a mere intermediate continuation of the several parts, or original substances, extended in length.

THREE years this little Rudiment is growing to perfection in the head of the new Root ; and till the end of that time it can never be seen perfectly : nor till that time does Nature send it up above the ground.

IN the mean while a few slight and simple Leaves are formed. They rise from the same Flešhy Substance of the Root, which is the original of all the Plant ; and their use is to draw nourishment from the air, and to assist the course and current of the Juices in the Root, where the young Flower is nursing.

AT the appointed period rises the Flower, supported by a Stalk, and covered by the Leaf, which serves it as a cup, till it is hardened enough to bear the air : then the Leaf expands, and leaves it free to blow, and gain its colour ; and the Stalk rises above its insertion, to give the future Seeds more freely to the winds.

THE Rudiment of the Flower, while it remains at the Crown of the Root, is a continuation of the several substances of which the Root itself is formed. The Process lengthens from the body of the Root at the other end, but this Crown remains unaltered : it is the future Flower, tho' very obscure in all its parts. The Pith has its termination first in this Crown, breaking into many oval particles : which are to be the Rudiments of Seeds in the SINGLE ANEMONE, or the inner Petals in the DOUBLE.

THE Conic Clusters form a little swelling at the Head of the Root ; and next terminates the Flešhy Substance of the Root, in a multitude of delicate slender Fibres. These are to be the Filaments in the Single Flower ; or the Fringe of the Double. The Vascular Series forms its thick Ring : and the Blea is terminated by the three broad Scales, which are to be the three inner Petals of the Flower. The next substance, counting from the Pith, is the inner Rind ; and this terminates within the same Crown of the Bud in three more Scales, which are to be the three outer Petals. Last of all, the outer Rind forms a shaggy covering, which is, in time, to be the Leaf upon the Stalk.

THUS all the original and constituent parts of the Root are terminated at the Crown, in a Bud ; and, thus the imperfect Figure of a Flower is formed. All that is wanting is the effect of nourishment, and time ; to fill and harden these shadowy resemblances, into the real things they represent. As soon as that is done the Stalk is formed ; and the force of the ascending Sap shoots it upward. The several periods of its growth are represented at Figure 1, Letters a, b, c, d ; and in Fig. 2, the entire and perfect

perfect Plant is shewn dissected. We see there the illustration at large of what we traced out in the Bud in little; and perceive distinctly how each portion of the original substance forms its part of the Flower; and in that terminates.

THE Leaves which rise first, serve only to draw moisture from the air, to evaporate the abundance of that received from the earth, and to keep up the course of a circulation in the Juices, while the Bud is forming. The Stalk, which afterwards supports the Flower, is raised originally from the Flesh of the Root. It is covered with absolute continuations of the Blea and Rinds, and is nothing more than a lengthening of that Neck by which the Rudiment of the Flower was first connected to the head of the Root; which Neck is no distinct substance, but only the place where the arch of Flesh rises from the Root; and the part where the several Coats become first attenuated for the formation of a Flower. The Flower is the enlarged Bud which crowned the head of the Process; and the Stalk is the continued Root supporting it above ground: it is no way altered but in consequence of that situation.

To trace the parts, and to ascertain this system, I have represented an entire Plant of the ANEMONE in flower, cut open, with its Root, even to the extrem Fibres.

BEGINNING with that point at the Head or Crown of the Root where the original Vegetative Power resided, the whole is thus performed.

THE Fleishy Substance, which was the original point, now surrounds the Pith of the Root, in form of a greenish line, Fig. 2, 11; and from the part m, whence it began to grow when first formed, rises a Process or part of its surface, which forms the Flesh of the Stalk of the Plant; the other way also from the same point runs the full Coat of Flesh, following the form of the body of the Root obliquely downward. This Fleishy Substance which surrounds the Pith of the Root, sends portions of itself into the Fibres, covered with the proper Coats; and in these there is a Pith, but not continuous with that of the body of the Root. These Fibres are of a vast length, and at their ends are very minute; but they are not open at the extremity, as has been thought. They are closed; and the several substances which compose them surround the Pith there, as they do elsewhere; but the whole Rind is spongy. That nourishment which was hitherto supposed to be drawn in at their extremities, is absorbed by the whole surface. Thus I suspect it is also with the Lymphatick Vessels of Animals: indeed, I think, I have seen it.

AT the Head of the Root, or from the original point upwards, shoots a Stalk. This arises absolutely and solely from the Flešhy Substance of the Root; not at all from the Pith, as has been supposed: and tho' this Rudiment of a Stalk be the original Vegetative Point in the Plant, yet we see all about it instances the most plain and obvious, that the same Flešhy Substance is able, from any part or point whatever, to shoot up other Stalks. We see upon the Root the originations of several Buds of different growths, and containing the Rudiments of Flowers more or less advanced. All these rise plainly also from the Flešhy Substance; not from the Pith of the Root at all: they are separated from it by a plain greenish line; which is the Flešhy Substance in its whole body, and is carried between them and the Pith.

THE Stalk rises in the same manner. The Flešhy Substance of the Root sends up a thin portion, which rises immediately covered with its three Coats, the Blea, the inner, and the outer Rind, and forms presently the Vascular Series, and the Conic Clusters. These run up uninterrupted from the Root into the Stalk: but the Pith of the Root does not, nor possibly can; for the body of the Stalk is not formed of the entire thickness of the Flešhy Substance of the Root, but only of a part of it; and the remaining part surrounds that portion of the Pith in the same manner as all the rest, separating the center of the Stalk from the central substance of the Root entirely. Fig. 2, *n*.

THUS rises the Stalk of the ANEMONE; and tho' it derives no Pith from the body of the Root, it quickly has one: for it is in the nature of the Flešhy Substance, wheresoever it is lodged, to shoot the extremities of its Vessels inward, and these form a Pith in the Stalk; just as those of the original morsel formed that in the Root; and just as the Flešhy Substance formed it in the Fibres. The Stalks and Fibres are constructed exactly alike in this respect: both have a Pith, not derived from the Root, but formed from themselves; and distinct from the central substance of the Root; not only as being discontinuous, but as being looser, and more spongy: distinct equally in place and substance.

IN the lower part of the Stalk the several Coats are white and delicate, so that it is hard to trace them distinctly, except before the most powerful Microscopes; only the Pith is plainly separated from the rest, being looser, and more spongy.

IN a second section, taking that part which is just above the ground, they appear very distinct: the outer Rind is brown and tough, the inner Rind is purplish and spongy, but thinner than in the Root. Next comes

the Blea, which is white, and in considerable quantity; and within that the thin, green Vascular Series; then the Fleſhy Substance, which is green, and nearly equal to the Blea in thickneſs: Within this is the hollow of the Stalk filled with Pith, ſurrounded with the Conic Cluſters. All theſe parts may be ſeparated by maceration; and thus we are to follow them up the Plant.

THEY appear in this diſtinct form all the way up to the Leaf upon the Stalk, *c*, where the brown and tough exterior Bark ſhoots outward, expands, and forms that Leaf. It continues into it, terminates in it, and is there entirely loſt.

AT this joint of the Stalk there is, as it were, a new ſhoot made. The Stalk above this Leaf is not a continuation of the Stalk below; but a growth of a new one: juſt as that from the head of the Root. The Proceſs of Nature is the ſame in both; and one being underſtood the other is evident.

As the Stalk riſes to this part where the Leaf is placed, it grows thicker; but it grows alſo hollow, *p*. The Pith, ſuppoſed ſo eſſential to the Plant, is, in great part, obliterated here; and there ſeems an end of the Stalk: for the outer Rind is gone off in the Leaf, and the great Fleſhy Substance comes to a kind of termination, ſurrounding the top of the Stalk in this part, juſt as it did the Root at the Crown. There are three ſubſtances which ſurround this fleſhy part, the Vascular Series, the Blea, and the inner Rind: theſe do not come to a termination, but continue themſelves up into a new Stalk; juſt as the three Coats, theſe two and the outer Rind, did from the Crown of the Root. See Fig. 3, *a*.

THE Fleſhy Substance, tho' it ſeems to terminate there, does in reality ſend up a part of its thickneſs alſo, which lines them, *b*; from this ſhoots internally a Pith: and thus is formed a ſecond Stalk upon the head of the firſt; which has all its parts, except the outer Rind. It conſiſts of one Rind, a Blea, a Vascular Series, a Fleſhy Substance, the Conic Cluſters, and a Pith; and thus it is continued to the Flower.

WHEN we ſplit this upper Stalk, and trace it thither, we find the Fleſhy Substance runs up in an uninterrupted courſe to the head of the new Stalk; and its Pith forms the head of Seeds. The courſe is very ſingular and beautiful in this Plant; and it may be traced eaſily. The Fleſhy Substance runs up a little way into the baſe of the head; for the Filaments riſe thence; but as it runs out into theſe, it diminſhes in ſubſtance till at about one third of the height of the head there is nothing of it left: all the reſt is made

made up of the absolute Pith, and covered with Membranes formed only by its hardening Juices, Fig. 2, *k*.

If we begin at the insertion of the Leaf, cutting the Flowerstalk half thro', and gently separating its several substances, we shall first take up a tough and firm Skin: this is the outer part of the present Stalk, and it was the second or inner Rind in that below. It was there purple; it is here greenish: but it has still something of the original hue. If we draw a part of this off carefully to the head, we shall take off with it one of the three outer Petals. This Petal is a plain and evident continuation of its substance: as plain as the continuation of the outer Rind into the Leaf upon the Stalk. The formation of the Petal from the Rind, is this at the point of the Flowerstalk which makes its summit, and where the Conic Clusters form that small head, the Receptacle of the Flower, this Rind of the Stalk swells into a kind of knot: just as the outer Bark did at the origin of the Leaf; and in this Knot or Gland, for such it truly is, the Vessels of the Rind which form it have many interweavings one with another, and swell out into little lumps. From these rise the Vessels of the Petal. But to understand this we must trace the matter yet deeper.

THIS second Rind of the Stalk, which appears outermost in the part now under examination, is not a simple Film, but has, as that of the Hellebore, and other Plants, a regular and large arrangement of Vessels. These are connected by two Films, which are mere simple Membranes. In this form the Rind runs up to the head of the Stalk, where it makes a peculiar Gland, and is thence continued into a Petal. The Vessels interweave with one another, without inoculation, and make the body of the Gland: this separates the two Films, which contained them in the common course of the Rind, to such a distance that the three parts can be seen distinctly. The Films still cover the Gland, as they did the Vessels in the Rind, and they are continued upward into the two sides of the Petal, Fig. 2, *f*, *g*. Thus one part of the Vegetable System serves to explain another; and the course of Nature being understood, is followed easily.

THE body of the Petal is composed of three substances, a vascular part in the center forming a kind of Flesh, and two Membranes, one on each side. The Rind itself is formed of the same parts, only they are more distinct in the Petal: and the use of the Gland is to give the substance of the Rind a kind of Root, full of nourishment, by means of which it may expand and form these Petals.

IN this Gland also are secreted the Juices, which give the Flower its colour: for the Petal while young is green, just as the Rind from which it rises: it has form first, and colour afterwards.

THE three outer Petals being pulled off, and the whole Rind with them, the Blea of the Plant appears: this is continued up to the bases of the inner Petals; and forms them just as the inner Bark did the others.

THESE being removed in the same manner, we have only the thick line round the base of the Receptacle, with the Fringe, and inner Petals of the doubleness left. There are three parts to form these; for there yet remains a Stalk, composed of the Flethy Substance, covered by the Vascular Series, tho' divested of three coverings, and lined with its Conic Clusters, and its Pith.

IF we separate the thin Vascular Series, this brings away the thick line round the Receptacle: then taking the Flethy Substance from its lining, the Pith, we bring away the entire Fringe, i. The Conic Clusters terminate in the Receptacle itself.

THE Flethy Substance of the Stalk runs up to a small height beyond the Petals, and there divides itself into the Filaments, which compose the Fringe. Its whole substance goes off into them. They are formed of bundles of its Vessels covered with a Film, from their own extravasated Juice. The part above these is the Receptacle of the Seeds, an oblong Bud, formed merely of the Conic Clusters; and covered with a Skin of a spungy Substance, made from its drying Juices. On this rest the Rudiments of Seeds, constituted of the Pith; which, in the double state of the Plant, make the small inner Petals.

THIS Plant being considered as a third Stage in the Vegetable Orders, may serve, after the instances of the first and second in the COLCHICUM, and ACONITE, to explain entirely the course of the Juices in Vegetables, and the manner of their growth; and a just consideration of its Fabrick, after the knowledge of the more simple structure of those other two, will, I persuade myself, shew the truth of that system here proposed, which adopting, and uniting the two formerly received, establishes the growth of Plants upon the force of a Circulation of their most essential Juices; and their Nourishment and general OEconomy, in a great measure, upon that Evaporation and Absorption by their Leaves, which has been supposed to set aside the other.

IN all Plants a watery nourishment is received continually by the Roots; and during the night by their Leaves. The part of this proper for the increase of the Plant is secreted, and after two or three concoctions, delivered





ed to that essential part the Flesh of the Root: and after this the system of Evaporation serves the excellent purpose of discharging that moisture which had been drained off its useful parts, and making room for more.

Thus is a continual supply of fresh moisture received; and from it, by peculiar secretions, that part is separated which can increase the bulk of the Plant: This part is delivered to the Flesh, whose Vessels all returning upon themselves, it is carried round, in a circulatory motion. The distention and contraction of the Flesh, and other parts, from the various degrees of heat in the Atmosphere, giving the motion; and the Valves in the Flesh-Vessels, which open only one way, directing the course. From the Flesh are sent the Conic Clusters of Vessels into all parts of the Plant, which also give that kind of secondary Circulation we have named; and from the abundance of Juice in the Flesh, thus fed by the Roots and Leaves, rises a portion which forms a Stalk. In the most simple kinds, as COLCHICUM, even this intermediate part is wanting; in the ACONITE it rises a few inches, and then breaks into a Flower, where the Rudiment of new Plants are formed; but in the ANEMONE, the Flower being raised higher, there is a second growth of Stalk, the part above the Leaf rising from the arch of the Flesh at that Joint, just as the lower part did from the Root. Thus is a more complex Vegetable Body nourished by two circulatory systems, as a more simple one was by one such system; and it is easy to see from this, that in order to support the largest and most complex of all, there can require only so many more repetitions of the original circulatory system.

THEY erred who fancied a Circulation in all the parts of Plants; for the use of the exterior Coats is merely Absorption and Evaporation; but I must be allowed to say, since these plain facts confirm it, that neither were they right who thought Absorption and Evaporation gave growth to the essential parts of Vegetables. The Circulatory System lies deep, and has not been observed: the attention of the Curious being fixed on one point, drew their followers from the other. It is certain, that without that great operation the Evaporation by means of the Leaves and other parts open to the air, the Juices of the circulatory system could not be fed; for the same exhausted moisture would remain in the Plant: but, on the other hand, it is equally certain, that a vegetable body may be kept alive without the assistance of that operation. This is seen in those tuberosous and bulbous Roots which, for many months, have no Leaf, or other part above the ground, yet continue alive and healthy; and are ready, upon a change of the state of the air and earth, by heat and moisture, to shoot

shoot up of themselves those parts in which Evaporation and Absorption are to be performed ; and thence to grow.

THERE is something in this article more than has yet been observed : it is not alone for a few months in the natural way of growth, that a Root will thus remain alive in the ground without any Shoot above the surface. What Nature in her proper course ordains in these instances, accident, or art, may effect in a much more surprizing manner. Roots will remain alive, and in full vigour, several years, from various accidents, yet without sending up any Shoot ; and will afterwards afford Plants not only as perfect, but much stronger and finer than they would have done in the common course of things. This dormant state of Roots demands, and deserves the attention of all who pursue these studies. The fact is certain.

THERE is now in the collection of that great Patron and Ornament of the Botanic Science, the DUKE OF ARGYLE, a Root of the CANARY CAMPANULA, which is as full of health and vegetative life as a Root can be, and yet has made no Shoot for a whole year ; yet there is no cause to doubt that it will hereafter shoot a perfect Stalk. This is not limited to the Exotick Plants. I have known, by a peculiar accident, a Root of POLYPODY, on the stump of an old beech, live without any shooting up a Leaf five years, and afterwards, from a change in the condition of the place, grow with an uncommon vigour, with large indented, and almost lacinated Leaves. Much more might be said on this head, but the subject is yet new, and I would excite, and not anticipate the researches of others, on a point which promises to be replete with wonder.

C H A P. XXXVIII.

Of Extraordinary COURSES of the JUICES of PLANTS.

NATURE is never traced more happily than in her irregular productions ; but it requires to know her ordinary course first : the manner of her deviations prove the truth of those original laws we have discovered, and give a new species of evidence, as convincing as it is strange.

THE close of the last Chapter gave an instance of Nature doing less than she is wont in the same instances ; and in the present we shall view her method when she effects much more. The defect is a subject not yet ripe for explanation ; but it is not difficult to see that it will probably enlighten and confirm the present system : the excess is frequent, and has been

been long known, and often examined. The Luxuriant Leaves of Kitchen Garden Plants, the Curled Mallow, and the Danish Mint, and a multitude of others, afford instances of this excess in one kind, the Double and Proliferous Flowers in another; but the most singular of all, are those which regard the Fruits of Plants.

THE Excess in point of Curled and Enlarged Leaves, depends entirely on the effect of an abundant moisture in the ground, swelling the Blea, which makes their middle substance, and which, wherever it extends, carry the Membranes with it. As this is the consequence of an extreme quantity of nourishment affecting that part, an extraordinary addition of those substances to the Soil, which particularly strengthen the Flesh, causes Doubleness in the Flower, by expanding the Filaments into Petals, and often splitting them to increase the number; and those Manures which strengthen the Blea, without so great increase, in the same manner cause Proliferation, or the rise of one Flower from the center of another, in the stead of Seeds.

THESE subjects I have had occasion to examine separately, in two peculiar Treatises, the Philosophy of which, experiments have since repeatedly confirmed. The doctrine of Proliferous Fruits is a new subject: the Course of the Juices may be very strongly illustrated by it, and the present year has afforded a very happy opportunity in the succeeding instance.

C H A P. XXXIX.

Of the PROLIFEROUS PINEAPPLE.

AMONG a number of PINEAPPLES raised two years since in the Island of ANTIGUA, there appeared one of an extraordinary size and form; covered, as well as crowned, by its new offspring. This was brought into England, preserved in a kind of pickle and presented to her Royal Highness the Princess Dowager of Wales, who is pleased to honour these studies with her most gracious protection and regard. The Root, the height of Stem, and common circumstances of growth were the same in this as in other Plants of its kind; but the fruit, was, in the highest degree, wonderful in its construction.

IN the common PINEAPPLE the top of the Fruit is terminated by a Crown of Leaves, arising from a small fleshy Base; and this is properly a young Shoot, which needs only to be separated, and planted to grow.

The

The surface of the Fruit, from the base of this Crown to the Stalk, is every where covered with Tubercles, within which are placed the Flowers and Seeds of the Plant. In this most singular subject many of the Tubercles of the Fruit grew out into so many little Crowns, each formed perfectly as the natural Crown at the top of a common PINEAPPLE; and all as fit for growth. The Tubercles on one side of the Fruit, for a small space, retained their natural form, while the whole circumference beside was covered with these lesser Crowns so close, that they crowded one another. There were not less than seventy of these new productions on the single Fruit; and the whole appears to have enjoyed a state of vigour and full growth at the time when it was cut, which seems to have been about ten days before it natural ripeness. A Figure of it entire is given in Plate XIII.

SINCE we know from this strange effort of Nature, that the PINEAPPLE Fruit is capable of Proliferation in an extreme degree, it may not be impossible to turn the subject to account: for we know Proliferation in Flowers may be brought on by a peculiar management; and probably the same holds true of this: if it should prove so, the increase would be many times greater than any other way. It may not be foreign to the purpose, to hint so much, as to the possible utility of the Proliferation of PINEAPPLES: but our immediate business here is to examine in what manner nature produced this most extraordinary offspring.

I HAVE been permitted to cut the proliferous Fruit asunder, to assist in this research, and by comparison of its construction with that of the natural and common PINEAPPLE, I think the course by which these new Shoots were protruded may be found. The first Step toward this is, to know truly the structure of the PINEAPPLE in its usual state; for in this there is something very different from the formation of other Plants: That we may trace this from the first stage to the last, under our own sight, it will be proper to select a Plant raised from a Crown of a common PINEAPPLE. Its growth is this.

THE Crown of Leaves being twisted off from a ripe PINEAPPLE, there comes out with them that Flethy Base before named, to which they are connected, and from which they grow. When it has been sometime planted, Fibres are shot out from this Flethy Substance at the base, for seeking nourishment; and these, by degrees, grow to be so many Roots, of the thickness of a large Packthread, and of an extreme length. From their sides also grow numerous branched Fibres. As we plant the Crown in Pots,



Proliferous Pineapple.

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Pots, these Roots, when they have reached the bottom, turn up again, spread themselves thro' the body of Mould, and run up to the surface.

THESE Fibres rise in two, three, or more circles, round about the Fleſhy Baſe of the Crown; none from its bottom; that becomes callous, and is wholly uſeleſs to the growth.

IN this Baſe, and in the Fibres, equally, we may trace, by a careful examination, fix of the ſeven conſtituent parts of Plants. The Pith alone is wanting: This is wanting entirely; and we have here a proof of the doctrine before eſtabliſhed, tho' it be contrary to the received opinions, namely, that the Pith is not an eſſential part of Plants; ſince here is one without it.

THE diſpoſition of the parts in the PINEAPPLE is not exactly as in other Plants, but is peculiarly adapted to the nature of the growth. Whether we examine a Fibre of the Root, the original baſe of the Crown, or the riſing Stalk, which is a continuation, or farther growth of that baſe, we ſee the ſame conſtruction: nay, we may trace it thro' the Fruit itſelf.

THE beſt part for examination is the Stalk. A thin ſlice of this laid before a ſufficient magnifying power, ſhews diſtinctly, 1. a thin colourleſs outer Bark; 2. a thick green inner Rind; 3. a thin Coat of pure Blea; this is of the colour and aſpect of a fine rich Jelly, a little tinged from the inner Rind. The Fleſh of the Plant follows but this is very ſingularly diſpoſed; it is not connected into a body, nor does it make a regular circle in the Stalk. We know the Fleſh in all Plants is vaſcular; and in this ſpecies the Veſſels are diſtinct. They are as thick as a ſmall Twine; yellowiſh in colour, and plainly hollow; and theſe with a large proportion of the Blea, make up the body of the Stalk. The two more delicate parts remaining are to be ſeen only with great magnifiers, for they are both minute. Upon the Coats of thoſe Veſſels which are neareſt the outer ſurface of the Stalk, runs the ſeparated Vaſcular Series; and on the inner ſurfaces of thoſe near the center, and thoſe only run the Conic Cluſters. The firſt are pale brown, the ſecond green; ſo their colour ſerves to diſtinguiſh them; the abſolute Fleſh Veſſels being yellowiſh.

IT may appear ſingular, that the Blea of the Stalk in this Plant takes the place of Pith, for ſo it does, mixing itſelf every where between and among the Fibres, and occupying even the center. But neither this diſpoſition of that part, nor its quality, will ſurprize us, when by tracing the courſe farther, we find this Blea is deſtined to make the Pulp of the Fruit.

IF we ſplit the new-planted Crown of a PINEAPPLE ſoon after it has begun to grow, we ſhall find the Fleſhy Lump within, beginning to lengthen

then into a Stalk ; and very soon the Rudiment of another Fruit is seen upon its top, and on the head of this, its own small Crown. Thus is the propagation of this Plant a most clear instance of what has been before asserted, that all Vegetable increase, however the term Generation may have been applied to it in some instances, is nothing more than a continued growth.

IF we next split down a half-grown PINEAPPLE with its Stalk, we see its construction yet more distinctly ; and may trace, with ease, the origination of the Fruit. A PINEAPPLE in this state split thro' the center with its Stalk, is represented Plate XIV. Fig. 2. The two Rinds, *a b*, make the surface of the Stalk ; within these runs up a pure Coat of Blea, *c* ; and in the midst are seen the Flesh Vessels, *d d*, intermixed with more of the Blea.

IN this section we see clearly, that the PINEAPPLE is not so properly a Fruit fixed upon a Stalk, as a Stalk swelling into a Fruit. To find how this is done, our attention must be directed to the part *e e*, Fig. 2, where the Stalk ends and the Fruit begins. Here we see plainly enough the continuations of the several parts. The outer Rind thickens, and gives origin to those small Films, or imperfect Leaves *f f f f* ; which rise under the Tubercles ; the inner Rind, *b b*, forms the Coat of the Tubercles, under which the Blea, *c c*, swells and expands into the body of the Fruit. A great quantity of it is sent up to this part, where it swells and stretches out the Stalk into a kind of oval form, and ripening, becomes the delicate Pulp of the Fruit, *g g*. All this while the Flesh Vessels, *d d*, with their concomitant lesser vascular systems run up strait thro' the center of the Fruit, not separating to any greater distance, but forming the same kind of loose column they did in the Stalk itself. The extension of the Blea is marked with the Letters *g g*, in Fig. 2, and the plain course of the Vessels running up its center, at *b b*, there is no difference between the Flesh Vessels of the Fruit and those of the Stalk, except that in the Fruit they are smaller and more numerous, having divided at the part *e e*, and sent off a few very delicate portions sideways and obliquely upwards, *i i*, which are to give origin to the Filaments within the Flowers lodged in the Tubercles, *k k*.

THIS is the structure of the Fruit of the PINEAPPLE, whose small Flowers are formed within those Tubercles, of all the parts, as in other Plants. But in the mean time that essential substance the Flesh of the Plant, which has continued its strait and upright course thro' the Fruit, when it has reached the summit forms a new solid Substance, the Part *l*, which is the Rudiment of a new Plant, and from which rises the Crown
of

of Leaves. This terminates the growth; and this being ready to take Root, and grow again, Nature, in a manner, trifles with the Flowers, and is little solicitous about Seeds.

THE little mass of Flesh is formed where the Flesh-Vessels terminate at the head of the Fruit, is the most essential part of the Plant, the Seat of Life of the succeeding Offspring, and the point from which all is to grow. We are interested therefore to understand this distinctly. It is thus formed. When the Flesh-Vessels have arrived at this, their extream growth, they prepare to return upon themselves: At the point *e*, the base of the Fruit, each divided into several smaller; but at the summit, *l*, they again divide into almost innumerable and extremely minute threads. The Coats of these, which are very tender, suffer a part of their Juice to oze out: this part is white, like Cream, and it soon thickens. The fine Flesh-Vessels having returned in arches at the summit of the part *l*, marked *m*, return in an elliptick form, as in the globules of Farina of other Plants, to the base of that part, *n*, and there, while some run down, the greater part inosculate with one another. The Juice they have extravasated, forms a thick fleshy matter between them, and a great deal of the same white Juice being extravasated at the part *o*, where the Flesh-Vessels begin to divide thus minutely, this spreads itself round the Fleishy Lump already formed, making it a thick white Coat: and thus the base of the PINEAPPLE Crown is finished. The growth of Leaves is natural when nourishment is continued; for this base being composed of the Flesh of the Plant, can produce all the other Parts; and the two Rinds, which its extravasated Juices form, make those Leaves.

THIS is the structure of the PINEAPPLE in its natural state; and from what we have seen of the Vegetable Nature it is plain this Crown, when committed to the ground, must grow. This Fleishy Lump has the same Construction with a Globule of Farina, only it is more largely formed. The elliptick Rings are larger by many degrees, and there are vast numbers of them. The white Juice which thickens between the Flesh-Vessels, and round them, is the rich Blea of a new Plant; and the two Coats are given it by the hardening of its own Juices in the Air; as they are given to all other Plants. Therefore this Fleishy Lump is the natural original of a new Plant, which has shot its crown of Leaves while it remains upon the parent Stalk, as the original elliptick Ring of the Farina in other Plants does its Seed-Leaves; and like that, when committed properly to the earth, it is ready to grow.

THIS construction of the common PINEAPPLE will be seen distinctly in the section Fig. 2; and this being understood, the Proliferation of the singular Plant here described, which to an untaught mind would seem so wonderful, may be most clearly explained.

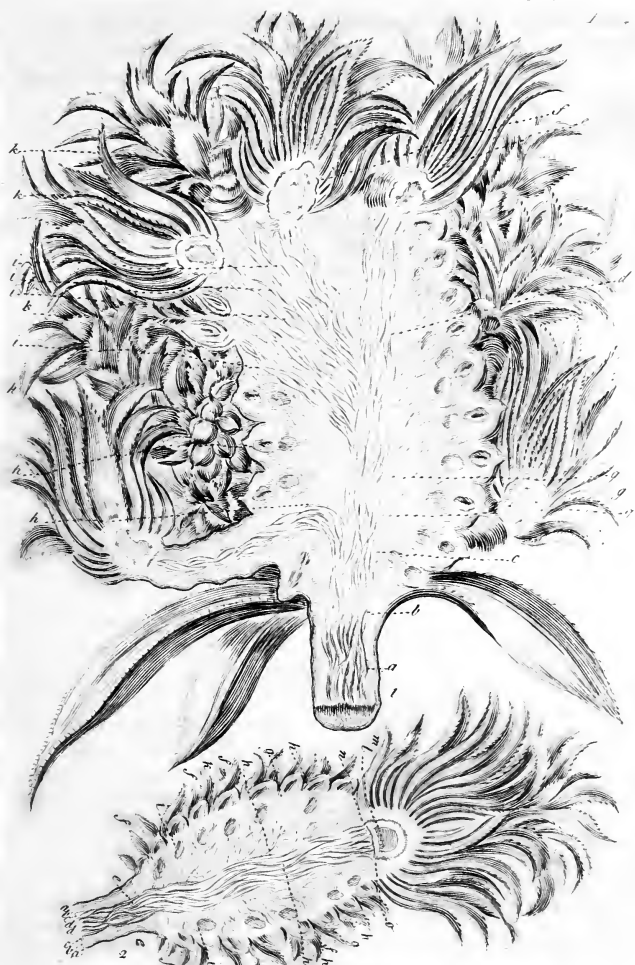
WHEREVER the Flesh-Vessels of this Plant form, by their termination, a Flethy Lump, as that at *l*, there is the original of a new Plant: the extravasated Juices of those Vessels form a Blea, and the two Rinds are given this by the air, as in all other cases.

IN the natural and common state of the PINEAPPLE, the whole Body of Flesh-Vessels runs up to the Summit of the Fruit; and only a few very minute Branches from them are sent off sideways toward the Tubercles, for forming the Filaments of the Flower. But if luxuriant nourishment, or any other favouring Accident, cause the Flesh-Vessels to be so strong in Vigour that these side Branches, naturally minute, become enlarged, and are like those of the middle Column, then they will terminate at the Surface, not in their own peculiar Manner, as Filaments, but in the same way as those of the middle Column: that is, there will be formed at the extremity of each Cluster, such a fleshy mass as that at the Letter *l*, in Fig. 2; and from this Leaves will grow. It will terminate the Flesh-Vessels of the old Plant in their natural way: that is, it will give the origination of a new one; which will obtain its Crown of Leaves while it remains upon the parent Stock; and when removed from it, will be ready to grow. The Terminations of these Clusters of enlarged Branches from the Column of Flesh Vessels, must be at the Tubercles of the Fruit; because those Branches are directed only thither; consequently, it is within a Tubercle only each of these fleshy terminations must be formed.

WE thus see from Reason, the necessity of what appeared so strange in this great Fruit: for if any cause could enlarge those Branches of the Flesh-Vessels which go to the Tubercles, in the natural state of the Plant, they must, instead of Filaments in a Flower, form new originations of Plants in those Tubercles: these must have their first growth on the Plant; that first growth is a Crown of Leaves, and consequently, each Tubercle to which such a quantity of enlarged Branches went, must, instead of containing an inconsiderable Flower, burst into a full Crown.

THE section of the Proliferous Fruit at Plate XIV. Fig. 1, which is exactly done from Nature, is a plain illustration of this system: and very happily a part of the Tubercles of this curious Specimen, having retained their original and natural condition, we see this alteration most distinctly.

IN



Sections of Pineapples.

1. Asparagus - 1 bunch
 2. Beans - 1 bunch
 3. Broccoli - 1 head
 4. Cabbage - 1 head
 5. Carrots - 1 bunch
 6. Cauliflower - 1 head
 7. Celery - 1 bunch
 8. Corn - 1 bunch
 9. Cucumbers - 1 bunch
 10. Eggplant - 1 each
 11. Garlic - 1 bunch
 12. Green beans - 1 bunch
 13. Kale - 1 bunch
 14. Lettuce - 1 head
 15. Lima beans - 1 bunch
 16. Mushrooms - 1 bunch
 17. Onions - 1 bunch
 18. Peas - 1 bunch
 19. Potatoes - 1 bunch
 20. Pumpkin - 1 each
 21. Radishes - 1 bunch
 22. Spinach - 1 bunch
 23. Squash - 1 each
 24. Swiss chard - 1 bunch
 25. Tomatoes - 1 bunch
 26. Turnips - 1 bunch
 27. Zucchini - 1 bunch

28. Asparagus - 1 bunch
 29. Beans - 1 bunch
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 31. Cabbage - 1 head
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IN the split Stalk, at Letter *a*, we see the Flesh-Vessels, large and few in number, pursuing their plain course up the Stalk: at the base of the Fruit, *b*, they divide; and in the Column, *c*, which runs up the middle of the Fruit, they are smaller, and more numerous.

LUXURIANT Nourishment having been afforded them, at the point *d*, this Column splits; and instead of one Crown, the natural termination of a PINEAPPLE Fruit, there are formed two of those fleshy bases, *ef*, and these sending out Leaves, as usual, there are two Crowns formed in the place of one.

ON one side this middle Column of Flesh-Vessels has sent out a number of Clusters of small Branches, as is usual, and these keep their natural course and proper size; and run to the Tubercles for which they are destined, in a right form for constituting Filaments in the intended Flowers of the Plant: these Tubercles therefore keep their natural form; and even, on the other side, there are two or three Clusters, *bb*, which hold the same unaltered condition, and therefore terminate at natural Tubercles: but for the most part on this side the figure; and thro' the greater part of the body of the Fruit, we see those Clusters of Branches from the central column of Flesh-Vessels, which should have held the minute condition of those at *g g*, and *bb*, in Fig. 1; and of all those, *ii*, in Fig. 2. enlarged to a degree in which they are no longer Clusters of Ramifications, but so many Columns of full Vessels, as at *iiiiii*, Fig. 1. like in dimensions, and in form, to the natural central Column in the Fruit. As they are like those in their nature, they must terminate as they do; not in Filaments, but in proper Crowns. This is the termination we see they have at *kkk*, and thus the PINEAPPLE becomes Proliferous.

C H A P. XL.

Of the EXTERNAL FORM and PARTS of PLANTS.

HAVING now gone thro' the consideration of the inner structure of Vegetable Bodies, the course of their Juices, and their manner of growth, we may rationally proceed to take a general and particular view of the several parts which are formed and fed by those Vessels, and that course of Juice. According to these the whole Vegetable Kingdom is arranged, first into seven great families; and afterwards into the lesser distributions of Classes, Orders, Genera, and Species. As the knowledge of the

the inner construction of Plants was necessary to the establishing a true notion of the origination and uses of their external parts; in the same manner, a just sense of the differences of those parts themselves, is needful to the understanding the characters of those primary divisions into Families, which are natural, and to which all others are subordinate, we shall therefore first enter into a detail of those external parts, and from thence proceed to the Characters of these seven arrangements.

THE general and obvious parts of Plants are four: the Root, the Stalk, the Leaves, the Flower; but there are others very important in their nature and office, tho' they were less regarded in the earlier times of Botany, these the great SWEDÉ first brought to the World's eye; and upon these he has founded often his Specifick, and sometimes his Generical Distinctions. Many of them had not been observed till he discovered them; and others, tho' they could not but be obvious, were so perfectly slighted in the accounts of Plants, that they wanted even names. These we shall enumerate, and distinguish here, under the consideration of the Parts of Plants: their utility in Systems will be shewn hereafter.

IN considering the Parts of Plants, Reason directs us first to the Root; because it is the part first formed from the Seed, and is the source of all the rest.

THE Root of a Plant is a Case or Shell of the Fleishy Substance, lined with a Pith, and covered with a Blea, and two Rinds; and is naturally buried under the ground. Immediately within this Shell of Fleish run the Conic Clusters of Vessels, which constitute the Ribs of the succeeding Leaves; and close upon its surface creep the Vascular Series, secreting that waxy matter which coats the Embryo in the Farina of the Flower. This is a Root whatever be its form; whether long or short, tuberous or fibrous, perpendicular or horizontal: but Bulbs do not come under this denomination; they are of various kinds, and different nature; the coated Bulbs are Buds, the solid are Placentæ; there is always a Root beside.

THE office of the Root is to produce all the other parts of the Plant, by extensions of that Fleishy Shell, which is its essential part. This forms by Processes from its surface Fibres downwards, and Stalks upward. It first nourishes the Seminal or Radical Leaves, by food drawn in at its Fibres; and is afterwards itself in part nourished by those Leaves it had produced; and fed so, that it is able to raise the Stalk for Flowering, and producing of new Embryo Plants.

THE

THE RADICAL LEAVES of Plants are those which rise immediately from the Root, with their own Footstalks; which have no connection with the Flowering Stalk of the Plant, but precede it in order of time; serve for its first growth, support and nourishment, till it has Leaves of its own; and then decay, and perish utterly.

THESE Leaves are always composed of three substances; a Rind, a Blea, and Clusters of Vessels. Sometimes they have also an outer Bark over the Rind, but not always. The Rind of their Footstalk is a continuation of the inner Rind of the Root, which expanding over the Leaves themselves, becomes a common Membrane: when they have an outer Rind, that also is produced simply by a continuation from the outer Bark of the Root. The Blea of these Leaves is also simply continued from the Blea of the Root: and the Vessels rise from those of the Conic Clusters of the Root; tho' not by plain continuation, but by a peculiar kind of vascular Base.

THE office of these Leaves is to evaporate during the day a great part of that Moisture which the Roots draw from the ground, after its nourishing Juices have been separated by the several Glands; and in the cool of evening, and during night, to receive from the air a quantity of moisture replete with the like nourishment for the Plant, which is to be secreted in the same manner. They serve also to keep up a perfect communication between the Root and rising Stalk; for the Vessels which form their Ribs, are sent from the Conic Clusters of the Root, which communicate with the Flethy Shell from whence the new Stalk rises; and they return again into it. This is a fact which has not been enough known. No Vessel of the Leaf terminates in the Leaf; they all run back into the Footstalk, and pursue their course to its Base, returning there upon themselves again. This forms what we have called a secondary system of Circulation, dependant on that primary one in the Fleth.

SEED Leaves agree with Radical Leaves in this Structure: it has been shewn in the course of the Vessels of the Seed Leaves of the Radish, and may be seen distinctly in the Radical Leaves of the generality of Plants. In those of the BLOODY DOCK, this return, and the inosculation of the Vessels, are very evident, because the Ribs are thick, and highly coloured: but of all Plants the COLOCASIA shews it most distinctly. In the Radical Leaves of that Plant, the main middle Rib, and the several side Branches, terminate in a large purple line, which runs round the whole circumference of the Leaf; and in the middle space between each pair of side Ribs, runs a delicate returning Vessel: this takes its origin from the Cord which surrounds the Leaf, and empties itself by innumerable Branches,
into

into the side and middle Ribs again. The Circulation of Blood, and Inosculation of the Vessels in animal bodies, before a Microscope, are not more palpable, or distinct, than those of the Vessels of this Leaf to the naked eye. If any doubts the system here established, let him read in that Plant its confirmation. We are not to suppose that the Juice from these returning Vessels is thrown into the same Vessels which contain the ascending part; that would create confusion. Each side Rib is composed of Vessels; some of which carry up the Juice to that Cord surrounding the Leaf, and others receive it returning from those inosculations. Nature scarce affords an object more beautiful.

THE STALK OF A PLANT is a tubular portion of the Flesh of the Root, lined with its own Pith and Conic Clusters, and coated with its Vascular Series, Blea, and two Rinds. It raises the Flower into the free air, and gives the succeeding Seeds to its power to scatter.

THIS is a kind of Root above ground, nourished, indeed, from the Root below, but like that producing all the external parts of a Vegetable Body. It has Leaves, whose origin, structure, and office, are the same with those from the Root; and it terminates in a Flower; its several parts dividing, and, when separated from one another, forming the organs of the Flower, the embryo Plant in the Farina, and the defending Seed.

THE Stalk gives place and origin also to several of those parts, to which the new Botany has adapted names, and which it has received into the number of specific Distinctions. The most considerable are those Spines which arm the surface of many Shrubs and Plants. These are of two kinds, and have distinct names according to the constituent part of the Plant from whence they take their origin. When the Spine arises from the Wood, it is called SPINA; when from the Bark, ACULEUS. We may in our language keep up the distinction, calling that which is fixed to the wood a THORN, and that which rises from the Bark, a PRICKLE.

THE HAIRS of Plants are next to be considered as appendages of the Stalk; tho' common also to the Leaves, in many Plants: these when they are permanent, afford marks of distinction. Their office is to discharge abundant moisture, when the nourishing Juice has been secreted from it.

FROM the Stalk also rise in many Plants a peculiar kind of thin substances surrounding the bases of the Footstalks of the Leaves. We see these in the Rose bush, and in Pease: They are different and distinct from Leaves, tho' in some few instances they supply the place of them; as in the APHACA, or YELLOW VETCH. The Term for these is STIPULÆ; we may call them FILMS.

FROM

FROM the upper part of the Stalk, in some Plants, there rise also a kind of thin substances of the nature of the former, but accompanying the Flowers, as those attend the Leaves: the Latin term for these is BRACTEÆ; we may call them FLORAL LEAVES or SCALES.

TENDRILLS are another appendage of the Stalks of certain Plants. These are fine slender twisted Filaments, which tie the Plant, as it were, to some adjoining substance. They generally are found upon those Plants which have Stems too weak to support themselves, and yet too firm for twisting round Trees, or other bodies.

FINALLY, among the adjuncts of the Stalk are to be named those GLANDS which, in some Plants, are large and obvious. These are of various form, but they have only one office, which is to separate and discharge the redundancy of that nourishment which has been sent to the part where they are placed. These grow sometimes on the main Stalk of the Plant, sometimes on the Footstalk of the Leaf, and in some Plants on the Leaves themselves.

IF to these parts we add the Buds of Trees, and of Perennial Plants, we have all that the new Botany has adopted as distinctive parts, on this foundation. These Buds are so many small Proccesses of the Flesh of the Plant; formed, as has been shewn in the ascendant Shoot of the Hellebore Root, and in the Buds of the Anemone; covered with Films and Scales, or with imperfect Rudiments of Leaves, and ready, when the season calls, to grow out into entire Plants.

THE FLOWERS of Plants, are the termination of their growth, and the seats of a new progeny. They are usually distinguished by a gaudy colour; but not always. There are four conspicuous parts of which they consist when perfect, but one or other of these is often wanting. The four natural and conspicuous parts are, a Cup, the Leaves of the Flower, which we call Petals, the Filaments, with their Antheræ or Buttons, and the Rudiments of the Seeds, naked or under cover of a Fruit or Seed-Vessel. Beside these three are two other parts of a Flower less regarded; these are 1. a small head crowning the Stalk, and giving rise to the Petals or the Filaments, and called the Receptacle; 2. a thick Ring surrounding the base of this Receptacle, or placed near it, sometimes rising into peculiar bodies called Nectaria.

THESE are all the parts which we find in the most perfect Flowers; but in many kinds some of them are wanting: only the Filaments or Antheræ are found in all. These are essential to the Flower, because they contain those Rudiments of new Plants for the defence and support of which

the rest were formed; therefore no purpose would be answered without them. In several Flowers the Cup is wanting, and in many the Petals; in some the Receptacle is not distinguishable; and the Nectaria are obvious but in a very few: the Antheræ or Buttons, naturally crowning these Filaments, are found in all; and the Rudiments of Seeds usually in the same Flower, tho' sometimes removed to another part of the same Plant; and in some species to another individual.

THE Origination of these several parts has been distinctly shewn in the Plants already described, and it is the same in all. The Cup is the termination of the outer Bark; and consequently those Plants which have no outer Bark to the Stalk, can have no Cup to the Flower: The Petals are usually disposed in two series, and are distinct in their nature; tho' this has not been enough observed. It has been shewn here in the Hellebore; and it is universal in the Vegetable Nature, tho' not in all Plants so obvious. Of these two series of Petals, the outer are formed by the termination of the inner Rind of the Plant; the inner of the extremity of the Blea. Where these parts are wanting in a Flower, it is not that the inner Rind and Blea are wanting in the Stalk, for there is no Flowering Stalk without them. But they decay in those Plants, where their growth ceases, and do not expand into these parts of the Flower.

THE Ring which surrounds the Receptacle, and which in the Hellebore and Aconite rises into peculiar Nectaria, is the termination of the Vascular Series of the Stalk; and the Receptacle itself is formed of the extremities of the white Vessels of the Conic Clusters: between these rise the originations of the Filaments; these being the extreme terminations of the Flesh of the Plant: and the Lich forms the Rudiments of Seeds.

THESE are the Parts of Flowers, and these their several Originations. Their office we have shewn distinctly, in treating of the first growth of Herbs: and thus a detail of the external parts, their origin, and office, has given a Recapitulation of the System of Vegetable Nature. This distinct account of them will also have a farther use: it leads us to the first great arrangement of Plants into seven Families; and as the distinctions of these, one from another, are founded on the disposition, peculiarities, or deficiencies of those Parts, we shall hence understand their separate Characters.

C H A P XLI.

Of the SEVEN VEGETABLE FAMILIES.

THE knowledge of particular Plants can no way be so perfectly obtained as by tracing the very origin of their distinctions in their structure: he must first know what Vegetables are, as Vegetables, who would understand the particular subjects distinctly. Classical distributions, established without this foundation, have been therefore vague; and have insulted Nature: uniting what she had separated by large divisions, and separating what she had intimately joined. Hence, perhaps, it is, that among so many good and useful methods as have been established, there is not one natural. Hence *TOURNEFORT* separated the Annual and Perennial *ADONIS*; and hence *LINNÆUS* joined in one Class the Violet and Marygold, forced to it by his artificial Characters, tho' sensible it was repugnant utterly to Nature.

PERHAPS upon the foundation of a true Anatomy of Plants, a natural method may be established: for it is certain the forms of all the external parts depend on the disposition of the internal; and all their differences are founded there. On the different inner structure of the Vegetable Body under certain courses of its Vessels, evidently depend the differences which characterize the seven first Families; to the distinctions of which all Classes are subordinate; and as these original distinctions are truly natural, we may begin there safely.

THE seven Families are these. 1. The MUSHROOMS. 2. The ALGÆ, or Foleacious Sea and Land Plants. 3. The MOSSES. 4. The FERNS. 5. The GRASSES. 6. The PALMS. 7. The common Race of Plants. Their distinctions one from another are these.

1. THE MUSHROOMS are FLESHY; and are destitute of Leaves and visible Flowers.

2. THE ALGÆ are merely FOLIACEOUS, the entire Plant consisting of a leafy matter, without other visible parts.

3. THE MOSSES have Processes of the inner Rind for Leaves.

4. THE FERNS consist of a single Leaf raised on a Stalk; and bear their Flowers upon its Back.

5. THE GRASSES have jointed Stalks and undivided Leaves, and Husks to hold the Seeds.

6. THE PALMS have a simple Trunk, with Leaves only on the Top, and have the Flowers and Fruit in divided Ears.

7. THE common Race of Plants are such as those we have described in the preceding Chapters, which have their Roots, Leaves, Stalks, Flowers, and Fruits distinct and obvious; and have not the Characters of any of the six other Families. These Plants of the common kind have been the subjects of the preceding part of this work; it remains that we here enter upon the Characters and distinctions of the other six: and as the order wherein these are placed tends to lead us from the most simple of all gradually to the more complex, it will be most proper to select from that simplest Class the MUSHROOMS, the kind which is most simple of all, the TRUFFLE. The Construction of this Plant has not yet been well understood: and the Reader will, perhaps, be surprized to hear, that, plain and rude as it appears, it has all the essential parts of the most perfect Plants. This will appear upon a just enquiry; and no instance can more strongly prove the general law wherewith we opened the way to these enquiries, that there is a certain structure, peculiar to Vegetables, which constitutes them what they are, and gives them a right to the place they hold among the ranks of Beings; and that this is found in all Vegetables, those which are called the most imperfect not excepted.

C H A P. XLII.

Of the T R U F F L E.

THE TRUFFLE, having no specious parts, no Leaves, no Flowers, has been of old supposed to want also Seeds; and, with the Worms of putrefying substances, was long attributed to the equivocal Generation. Yet very early there were some thought otherwise; and later observations have gone farther toward ascertaining its History.

THE TRUFFLE has evident Seeds; but they are contained within its substance, under the Rind, and in the absolute Flesh. This is not singular to the Truffle; it has always been referred to the Mushroom Class, and many, perhaps all the genuine Mushrooms, have the Seeds covered. They are minute, and they require defence: they have, indeed, more occasion for it than merely from their smallness. The young Plant is, in a manner, formed within them, by that time they have their bigness: and it would perish if not well defended till their slight surface were tolerably hardened.

IT is for this reason Nature has given the protection of a defence to them all, lodging them within the body of the Plant, or covering them with Membranes. In the common Mushrooms, whose Seeds have been said to lie naked on the Gills, some have them placed in clusters, others singly: in the former kind I have always found them covered with a Membrane; and the latter, tho' it be less distinct, I think they have it. In the Boleti there is a spongy Membrane, which lines every Tube, and within this the Seeds are generated, breaking thro' it only as they swell. This is strange, because in both these instances the Male Flowers stand naked at a distance on the verge of the Tube, or the very edge of the Gill: but the delicate Farina of these easily pierces the natural openings in those Membranes, and then the Seeds swelling burst them. In the Hydnum they are covered with a kind of Tube, which is only a more delicate Membrane. In the Phallus, which approaches more to the Truffle, they are buried in a tough substance, which covers the head, and are only seen when it melts in decay, and becomes a liquor. In the Clathrus, still nearer the Truffle, they are lodged in the very central substance which fills the cavity of that Net in the original state. In the Elvela they lie under a very evident Membrane on the surface, which originally forms the upper Coat of the Plant, and which being pierced by their innumerable heads when they ripen, dries away, and lets them out in dust. In the Peziza they are absolute Fruits, in which the Seeds lie covered perfectly. In the Clavaria the Seeds are formed under the upper Coat, as in the Elvela. And in the Lycoperdon, to which the latest systems join the Tuber, the Seeds are contained in the absolute substance of the Plant, which is originally enclosed within three firm Rinds, and is itself of a tough consistence: but as the Seeds ripen, this intermediate matter dries away into thin Films and Fibres; and leaves them in a fine powder, free to the air.

THESE are the established Genera of the Mushroom kind; for they err greatly who refer the Plants which make mouldiness to the same name. In all these the Seeds are covered in the Plant; in the Phallus and Lycoperdon, they are absolutely contained in a Fleishy Substance.

IT is thus Nature has lodged them in the TRUFFLE, which is the most fleshy of all the Mushrooms, and its construction is this.

WE see a round, or nearly round ball, whose surface is composed of a kind of points, each composed of four parts, and divided by four ridges raised above the Skin, and placed like rays of a Star: 1, 2. It is evident to sight, in the fresh-cut TRUFFLE, that this Bark is distinct from the

Fleish

Flesh of the Plant ; but it is difficult to separate it, without heat and long maceration.

IF some TRUFFLES be cut into slices, and stewed in river water, there rises to the surface a peculiar matter, which, as it cools, forms a tough Skin like Vellum. This was originally a Juice lodged between the outer and second Rind, and it held them fast together. When the boiled TRUFFLE is divested of this, let it be macerated eighteen or twenty days in water, and the parts will separate. We then take off a brown outer Rind, which is rough, unequal in its texture, and very thin. This does not form, but merely covers the Tubercles on the surface. 3, 4.

UNDER this we find a yellowish Coat, considerably thicker, 7, 8 ; but neither does this form the Tubercles : it, like the other, only covers them. The Ridges are plain in this, 9, 10 ; and the true form of the Tubercle is better seen here than in the other : at the Head is a little opening ; and there is the same in the outer Rind, on the Head of each Tubercle, only its naturally uneven surface renders it more difficult to be distinguished.

BETWEEN the brown and yellow Rind lies the tough, gluey matter which formed the Skin separated in boiling, and which, till separated, held them so fast together.

THE body of the TRUFFLE being thus cleared from its two Rinds, is of the same form that it was while they were upon it ; it now appears a mass of whitish Jelly, rising into so many angulated Tubercles, 11 : and, when cut asunder, there is the appearance of another Coat ; but this is a deception. There seems a Coat of a very considerable substance rising into these Tubercles, and of some small thickness, even in the spaces between them, covering a brown fleshy matter. 12.

THIS is no more than an appearance. The whole white substance is the pure Pulp or Flesh of the TRUFFLE ; and it is this which absolutely forms the Tubercles. In these, and for some small thickness between them, and below them, it runs in the same pure form ; and is distinguished by its white colour : all within this is brown. This difference of colour, great as it appears, is owing to innumerable Seeds. The colour of these is a dusky brown ; and they lie so close, that they give the same hue to the whole inner part, when the naked eye only sees it.

IN a thin piece laid before the Microscope, Fig. 13, we see the superficial part is white, because it is pure, unmixed with Seeds, and of a closer texture ; and within it is of the same matter, white as that, but more spongy, and intermingled with these innumerable Seeds. It is the same difference that we see between the solid Pulp at the bottom of the Puffball

ball Lycoperdon, and that looser part of it above, which is intermixed with Seeds. The difference is the place, very little more.

THIS white substance of the TRUFFLE is spongy, and very like the spongy ends of the Hellebore Fibres; it would take nourishment at every Pore; but that would be too much; therefore Nature has given it this double Bark, lined between with a substance impenetrable to water and indissoluble in it, as appears by its floating separate and entire in boiling; and has left only a certain proportion of its surface open at the Head of every Tubercle. There, and there only, the white Flesh or Blea of the TRUFFLE is naked, and there only it draws nourishment.

WE see thus what are the Coats, and what is the Flesh or Substance of the TRUFFLE, how they are connected, and how they are disposed. There remain the Seeds to be considered, and their Receptacles. For they erred who, having seen Seeds in the TRUFFLE, thought they were laid loose in this Flethy Substance.

THE body of the TRUFFLE, within the circle of pure Flesh, is composed of one great Vessel, absolutely continuous, but folded, and, as it were, divided into a multitude of oblong and irregular parts. There are fifty, sixty, or more of these in one TRUFFLE; they lie close in the center, and they run out toward the surface in all parts, Fig. 14: they terminate in obtuse ends, at a small distance within the surface; the white and pure Flesh always covering them. These parts of the great Seed-Vessel are all full of Seeds; and the Membranes are so strong, that they keep them securely in their places. It is therefore the pure Flesh is always white, and has none of them among it; it is, indeed, impossible it should in the perfect state of the Plant, for the Membranes absolutely envelop them.

By long and careful maceration we may dissolve this Pulp or Flesh entirely off, and leave the Vessel naked. This might lead us to call it a Coat; but that it is continued to the center: it not only covers, but separates the Lobes of the great Seed-Vessel; and it is this which makes the marbling of the TRUFFLE. All we see brown is this prodigious and variously convoluted Seed-Vessel. The white Lines that run among it are so many portions of the Flethy Substance, continued from the outer circle of it, and running wheresoever the convolutions of the Seed-Vessel give it way: This is therefore not a Coat, but a peculiar matter, serving, as the Root; for it gives all the nourishment. Long boiling burts the Vessel, and swelling the lines of pulp between it, lets loose the Seeds among that matter. Fig. 15.

WE have seen the Vessel cleared of all the matter, and we are now to examine its structure. This is very simple; it is composed of two Membranes; both pellucid; but the outer one the thickest. Fig. 16. The inner Membrane rises into little Blebs, like round Bladders, at small distances from one another, and these are properly the Seed-Vessels of the TRUFFLE. Fig. 17. Four Seeds are lodged in each, 18: when we see a smaller number, it is owing to the Knife cutting the Vessel in two.

EACH Seed is really a TRUFFLE. We see them at first small, round, and smooth, and they appear no more than Particles of the outer Membrane of the great Vessel, raised and loosened within the Bleb made by the rising of the inner Skin, Fig. 19: as the TRUFFLE grows toward ripeness they enlarge, grow dusky, and rough, 20; and in the end, while they are yet in the body of the TRUFFLE, they acquire even their brown outer Coat; and they are TRUFFLES; wanting only growth.

THUS we see the course of Nature in the formation of the TRUFFLE. The outer Membrane of the great Vessel is the essential part, analogous to the Fleishy Substance in larger Plants. This has its three Coats, the two Rinds, and the Fleish answering the Blea; and this inner Membrane in the place of Pith, from which, indeed, there run Fibrils, making a true tho' very light Pith in the Lobes and between the Seeds.

In all Vegetables the essential part, or substance, sends off at its extremity Particles, which being lodged in the Seed, are capable of growth into new Plants. In this plain Vegetable, the TRUFFLE, there is nothing of the apparatus of Filaments, and the other parts of a Flower. But Particles of the essential part, which is the outer Membrane of the great Vessel, separate themselves, and are defended by a little Bleb of the raised inner Membrane. Here they float in a clear liquor, and they immediately grow. They are at first only round pieces of the Membrane itself; but this forms all its own Coats, as the Particle in the Seeds of Plants does; and by cutting TRUFFLES at various periods of ripeness, we may even see this done. First the Fleish, or pure Pulp, is formed, and the little Seed then is somewhat larger, and more opake. After this the yellowish Rind is formed, and it is then more opake, and somewhat coloured, Fig. 21: and, finally, the outer Bark is also formed; it is then obicure and rough, Fig. 22. It is a perfect TRUFFLE, and requires only to ENCREASE in size to be what its parent was.

ALTHO' the Seeds of the TRUFFLE are thus extremely numerous, and to the Microscope very plain and distinct, nothing is more difficult than to get them clear of the Vessel, and separate for examination. The Reason
is

is, that the Bleb wherein they are contained, as in a Seed-Vessel, is part of the inner Membrane of the great Vessel itself, and that Membrane is no where stronger than in the place of their connection. Maceration answers the purpose of separation on all common occasions, but the whole substance of the TRUFFLE is tough, and remains a long time unaltered in water.

WITH great difficulty, after very long maceration of extremely thin slices of the TRUFFLE, they may be thus separated imperfectly. Lay a thin macerated slice on a Plate of Glass before the Microscope: first wash it several times in clean water, and then lay on it a large drop of filtered water. This care is needful, that no small bodies may be accidentally on the Glass. Then observe with the Microscope where the edge of the piece is broken and most ragged: lay the Glass upon white Paper, and with a Camel's-hair Pencil very gently rub and sweep, as it were, that part, carrying the short strokes outward. On laying it before the Microscope again, there will be seen some separated Seeds; but they will not float loose, the Bleb or Film wherein the few are contained, as in a Capsule, comes off entire. Thus, however, we have them separate from the Plant. We see this Capsule now distinctly: It is a delicate, colourless, transparent Membrane, and is a little inclining to oval: at the smaller end there is a plain Neck, by which it was originally fastened to the Membrane whence it rose; and the Coat is, in this part, lacerated. The Seeds lie regularly in this Capsule, with a small opening between them in the center, and a great deal of space outwardly.

WHEN we have sufficiently examined these Seeds in their Capsules, the way to get some of them loose is this: in a drop of the same kind of water, lay another very thin piece of the macerated TRUFFLE; observe the thinnest edge of this, and with a small Pencil of Hog's-bristles stamp upon the TRUFFLE in the water, and by this means a great many of the Seed-Vessels will be loosened, some of which the ends of the Bristles will have burst, and the Seeds will then be visible distinctly, for many will get out of them, and float loose in the water.

To see the Progression of the Seeds in growth, we should take the TRUFFLE in three states for this experiment: the first when it is full of very young Seeds; the second when they are half grown; and the third, when entire. These were the observations I made on them.

IN those TRUFFLES which have the Seed very young, the Bleb which holds them is small; and each Seed, when seen separate, is a roundish

pellucid Lump, only thicker in one part, where it originally grew to the outer Membrane. Fig. 19.

IN those which have the Seed advancing toward ripeness, it is less clear than before, and begins to shew some degree of roughness in the Coat. Fig. 20, 21.

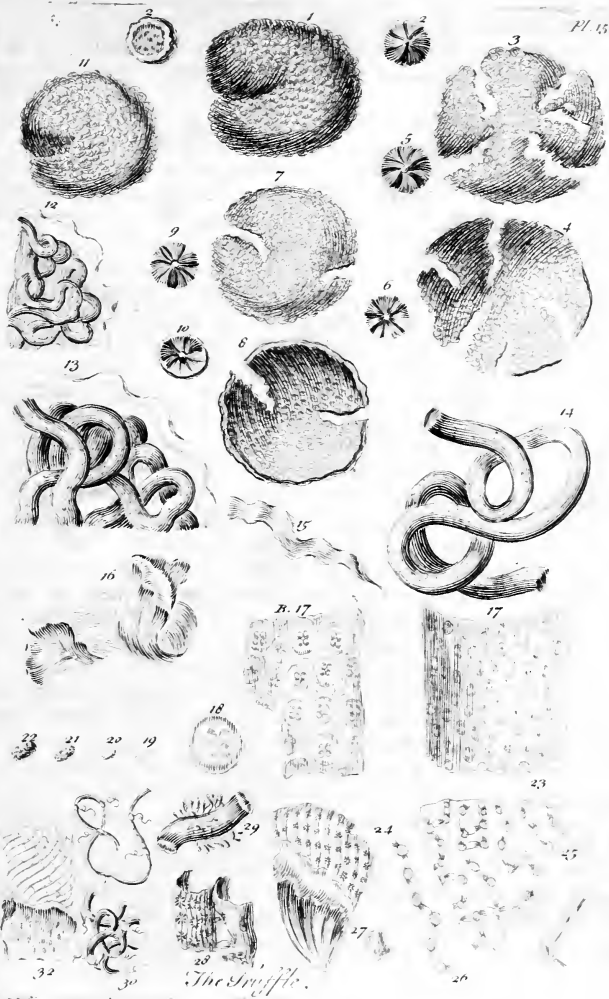
IN the perfectly ripe, the whole surface is covered with Tubercles, as in the entire TRUFFLE, only they are longer and slenderer. Fig. 22.

SPIRIT of Wine, even by long steeping, makes no change in the thinnest slices of the TRUFFLE, except that contracting and hardening the substance, the Seeds are seen less distinctly in the slices, and are more difficult to be separated than when in the maceration.

THE outer Bark of the TRUFFLE is brittle beyond almost all Vegetable Substances: it is therefore extremely difficult to get thin pieces of it pure for viewing the structure. The best are to be had from the angles of a Tubercle in a long macerated half-ripe TRUFFLE. Fig. 23. Examining these we find, this Bark is composed of jointed Vessels, and loaded with a brown coarse substance. The Vessels are themselves pellucid, and appear so between the several Joints; but at those places they swell out into more thickness, and are perfectly opaque. Fig. 24. They do not run in any regular direction, but are variously interwoven with one another, and go in that manner all over the surface of the TRUFFLE; uniting themselves at every Joint with the inner Rind, by many little Mouths. Fig. 25.

THIS shews why this Bark is so extremely brittle. The Vessels are very tender, and the Joints are loaded with a heavy matter: therefore the force and weight in moving these alone, would break them in the intervals; but they are also joined so firmly at every Knot with the inner Rind, that they must also break there; and these Knots are innumerable. For this reason, in whatsoever state of the TRUFFLE we attempt to separate its outer Rind, unless with very uncommon care, that part comes off in little scraps. The view of a piece from the upper part of a Tubercle, shews the structure most happily: the white Flesh appears naked in the aperture at the summit, and the Vessels form a kind of regular Fringe on the edge round it, running clear from the white substance, in a kind of rays.

THE inner Rind of the TRUFFLE may be separated somewhat better from the Flesh, but still with great difficulty, tho' from another cause. When we have a very thin piece of this clean before the Microscope, we find it composed of simpler, plainer, and less entangled Vessels than the other. We may perceive also, that these are contained between two Membranes, and buried, as it were, in a vast quantity of spongy Pulp. They are



are innumerable in the minutest piece of the Rind; their Coats are rough, their Cavities very small; and their Surface, at intervals, is fringed just in the manner of the middle part of the Fibres of Black Hellebore Root. Fig. 27. This Fringe plainly consists of Fibrils; and these piercing the Joints of the Vessels of the outer Rind, at their innumerable mouths, make the strict union there is of those two substances. Fig. 28.

THESE parts are all very small in the TRUFFLE, as are also its Seeds; but when sought with care, they are found distinctly. The inner Rind, even in very thin pieces, appears spongy, dark, and coarse; but in many trials made on the well macerated parts, some Vessels will appear distinctly. This Rind of the TRUFFLE does not preserve so exact a thickness in all parts, or terminate so equally round about the Flesh, as in the more regular Plants. It runs into that substance in many places, and is always terminated by a waved and very irregular out-line. And I have observed distinctly, that those Vessels which run nearest the Flesh, have the same Fibrils at certain distances, as the others.

THE Flesh of the TRUFFLE, tho' it takes the place of the Blea in Plants and Trees, has not its proper nature. In that part there are in other Plants, clear Cells, and coloured Sap-Vessels; but in the TRUFFLE it consists of Vessels only; these are, indeed, lodged in a white spongy substance, such as is found in the interstices of Vessels in other parts; but this is not formed into regular Cells, nor is it of any determinate Figure; it serves only to lodge the Vessels and to prevent their pressing upon one another. These Vessels are perfectly transparent, and they are jointed as the others, but at greater distances.

FROM the Joints of these run various curled and twisted, milk-white Fibrils in all parts where they touch the Membrane, and in no other part. There are also innumerable orifices on the surfaces of these Vessels throughout, by which they communicate with the extreme parts.

WITHIN this Flesh of the TRUFFLE is contained that great and most surprizing part, the Membranous Vessel, in which are lodged the Seeds. This is considerably thick, and perfectly pellucid. In most views it appears no other than a piece of an extreme thin Bladder; but with great Magnifiers we see Vessels in it; and they are numerous. They run upon its inner surface, and are fixed down to it; and the Membrane which lines it is their other Covering. These are the essential Vessels of the Plant; and I doubt not but pieces of this Membrane, cut off in any part, would grow.

THIS Membrane may be most distinctly seen in a piece from which, after due maceration, the Seeds have been wiped away in water, with a

Camel's-hair Pencil. The parts where each Bleb, or Seed-Vessel adhered, appear a little rough; Fig. 32. For the rest, the Membrane is transparent, and is not seen, unless in distinction from the more elevated Vessels; and the little Specks, or Rudiments of future Blebs for Seeds.

THE inner Membrane is a mere Film; it only lines the other, and forms the Blebs or Seed-Vessels. The Seeds of the TRUFFLE, tho' very distinct to powerful Glasses, are too minute for the management of the Gardener's hand in sowing. Probably they swell greatly when the TRUFFLE bursts with ripeness: for the Seeds of most Mushrooms do so. Those of the Lamellated kinds increase to sixty or seventy times their bigness, after they are fallen from the Plant, before they begin to burst for the growth of the included Mushroom.

C H A P. XLIII.

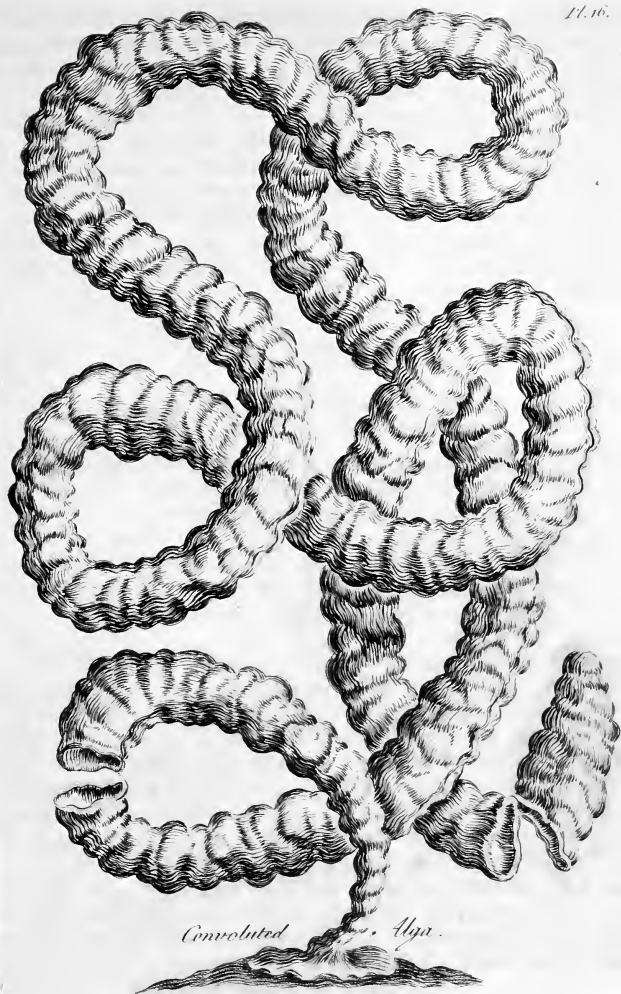
Of the CONVOLUTED ALGA.

THIS singular Species will give us as distinct an instance of the second Family of Plants, as the Truffle does of the first. The Character of these is to be foliaceous; and this is foliaceous entirely.

THE common OISTERGREEN, and the like, are Plants also of this class; and it is from those natives of the Sea the term ALGA has been taken, to express the entire Family: into which, perhaps, some Plants of too complex a structure have been admitted, even by Writers esteemed the most correct.

A SHORT description will be sufficient to illustrate this species, the very figure of which alone explains all we know of its parts and composition: yet even this, simple as it is, appears of a superior order to those plain flat kinds before named, whose whole character seems to be what the Philosophers have given as that of matter, Extension. All Plants merely foliaceous, are ALGÆ; this rises above the plain kinds, by being tubular, and elegantly folded. See Plate XV. What are its fructifications I have sought in vain: and tho' its matter be truly vegetable, perhaps its singular form is owing to a cause different from that of Vegetation.

IN some kinds of what are called Metallick Vegetations, the Stems and Branches, as they are called, are made by the ascending force of disentangled air. The bottom of the Vessels is covered with a rude mass of mineral matter, from which a bubble of air rising toward the surface, carries with



with it all the way, a thin coat of that mafs, which hardening in the liquor, appears long and hollow, and is called a Branch. In a manner somewhat like this the bottoms of the Ditches in our Salt Marfhes, are covered with a light, and flat foliaceous green fubftance, which fpreads evenly upon the mud. This is plainly the original of the Convoluted ALGA; and, perhaps, in this, not in the more fpecious upright form, we may fometime find the Seeds of the Plant.

A BUBBLE of the air, imprifoned between this green Coat and the Mud, may rife toward the furface; and as the Coat is tough and flexible, this Bubble may afcend clothed with it, as in the other inftance: the motion of the Water may give the Convolutions, as this gives the hollownefs; and from thefe combined Powers may arife the peculiar form, not of this alone, but of many of the Confervæ, which are alfo of this Family; and which, perhaps, have hitherto impofed upon the world as proceffes of vegetative growth.

THE Curious will receive this as conjecture: it is propofed no otherwife: but if fucceeding feafons fhew to me, or others, the Fruftifications of this Plant in its fimpler part, upon the bottom of the Waters, this opinion will be ftrengthened; and, perhaps, extended to more inftances.

THIS Convoluted ALGA which, from its place of growth, and its refemblance of prepared Animal Inteftines, the common clafs of Writers have called the Sea Chitterling, afcends without a Stalk, as it grows from no Root: where there is one of thefe parts, there naturally is the other; becaufe they depend upon, and are continuations, in great part, of one another. The furface of the plain Plate riles in a Tube, and afcends to two, three, or four feet in height: it is naturally upright; but it is fo weak, that the force of the water bends down its top; which riling again, and being again bent by the fame force, twifts the whole Tube about, in a manner, tho' more loofe, yet fomething like what Nature fhews in the difpofition of the Inteftines in an animal body. The furface alfo, by the fame impreffion, is crufted a little, as it continues to grow; and thefe preffures, fo often repeated, force down the new part of the Tube upon itfelf, at fhort intervals, and by that means make the indentings, fwellings, ribs, and furrows, which fhew their light traces lengthwife, and tranfverfely throughout the body of the Plant.

THE Tube maintains all the way a large cavity; and as the air has great fpace in it for expansion, it does not burft at top; but terminates in an entire plain and clofed end.

Tho' it originally rises from a continued Coat of the same matter at the bottom of the Ditch, its bigness gives the water so much power upon it, when moved by the Wind or Tide, that it is soon torn off, and floats loose. In this state it lives as perfectly as while there was a communication between it and the plain Coat at the bottom; and floats about all Summer.

C H A P. XLIV.

Of the SWAN'S NECK BRYUM.

IN this instance of the third natural Family of Plants, I have been obliged to have recourse to a new Character of Distinction; since those formerly established are, if not erroneous, at least equivocal. LINNÆUS supposes the heads we see on this, and the like Mosses, to be Antheræ, and the powder they contain a true Farina; and that the naked Seeds are lodged on other parts of the Plants. On this foundation he establishes the Character of the Mosses to be an Anthera without a Filament, and remote from the Female Flower. To me it had appeared, long before, that the Head in these Mosses is truly and properly a Seed-Vessel; and its Corona, a part little understood, or even regarded by others, I persuaded myself, from various examinations, contained a true Farina.

THIS system I laid before the Royal Society about twelve years ago; and they were pleased to do me the honour of printing it in their Transactions. Since that time one of the Linnæan School has endeavoured to revive the system of his master; and what he has done on the subject, appeared among the *Amœnitates Exoticæ*. The instance I selected in that paper of the Transactions, I think, was a *Hypnum*, one of the common Mosses which bear heads; and that by which I am about to support the same opinion here, is a *BRYUM*, one of a kind yet more common.

THE Linnæan system is supported by a Plant of a very singular kind, unlike the rest in its Fructifications, and perhaps, indeed, not properly a Moss. The subject is yet undetermined: the Reader will do me the justice to believe nothing could induce me to depart from the opinions of so respectable an Author, but what appeared to me the certain evidences of Nature. These I am about to lay before him; and till this matter shall be decided, as I could not adopt the Linnæan Characters of this Family which appear to me erroneous; neither have I ventured to deduce a new
one

one from my own. But as there is in the rest of the Plant a sufficient distinction, the inner Rind extending itself singly in the place of Leaves, a Character which so far as I have seen, is peculiar to the Mosses among all Vegetable Nature, I have fixed the mark of the Family there.

THE species which is here selected for the illustration of this Family, is one of the most common: the specimens used in the present enquiry were gathered from the low wall round the Reservoir in Hyde Park. It grows only facing the North and North-East: To the East, tho' the wall is wetter, there is none; nor to any other quarter.

THE Tufts are large; but each Globule is a distinct Plant: It flowers and decays. Be the Tuft ever so big, there are no other Plants in it but such as have heads in them for this season, or on the decayed remains of last. They entangle by their Fibres, but do not rise in Suckers.

THE Seed of February ripens in April, and is shed. Young Plants appear in October, and flower the February following. We see them on separate spots, but most are near one another. The Stalk rises from the center of the Globe of Leaves. The Leaves, that is the whole Globe, decay when the Seed is shed; so the old Plants appear deeper rooted in the Tuft than the others.

THE Seeds are light and tender: the greater part is lost; but those which fall upon the Tuft naturally succeed; for they have defence and moisture. The old Plants from which the Capsule rose, by degrees decay; and the Seeds which were at first lodged among them, swelled with moisture, and ready to strike, shoot out their Roots, and grow into Plants for the succeeding season.

WE see this Moss usually in roundish, or long Tufts, rooted in the mortar between the bricks of an old wall. Each tuft is composed of a multitude of Plants: We find these, tho' distinct at the head, yet entangled strangely by the Roots. The whole Tuft, at this season, consists of Plants in three states; some very conspicuous, being in their perfection; others, which require more examination to discover them, being less grown; and others in decay. The perfect Plants have a long Stalk rising from the center of the Globule, and crowned with its proper Head. Plate XVII. Fig. 1, x x x. The younger Plants consist of a green Globule, with a Head in the center; the top of whose Calyptra, or Cover, only appears, y. The decayed Plants have sometimes the remains of last year's Stalk, tho' usually it is fallen out before this time; and the Tuft of Leaves is no longer globular, but spread open, z: all greatly magnified.

THE

THE Leaves form this globular body for the defence of the Rudiment of the Head, consequently these are most compact before its Stalk is formed, and while it is yet entirely in their bosom: they are somewhat less folded over one another when the Stalk rises; but when it has done its office, and is decayed, they separate, and hang loose.

IF we separate a perfect Plant with care, at the time when it is in flower, we find it consist of three parts. A slender and bending Stalk, supporting the flowering head; a globular or oval cluster of Leaves growing round the base of that Stalk; and a long brownish Root hung about with innumerable Fibres.

THE naked eye sees no more; but few objects better deserve a more strict examination: the Microscope shews this little BRYUM a magnificent as well as singular Plant: differing not only in fructification, but in the structure of its parts, from all other Plants. See Plate XVII. Fig. 1.

THE Root is long, brown, and hung about with innumerable very long, and strangely entangled Fibres, it is abrupt at the lower end, not attenuated; and in the part between that and the base of this cluster of Leaves, mimicks a kind of Stem, but covered there also with the like Fibres, which rise from every part of it. The length and number of these Fibres from the side and base of the Root, and their various entanglings, those of one Root with those of others, make it difficult to break the mass; and often tye the several Plants so closely, that they seem to rise in the way of Suckers from one another: But careful observation shews them to be really distinct; the several Roots usually falling obliquely over one another. None are so easily separated as the old decayed Plants of the last year, whose Fibres are by this time withered away.

FROM the summit of the Root rise the Leaves which compose the Globe; and there are a few less perfect leafy Films between them.

THE Leaves which compose the Globe are six: the imperfect Films beneath them usually two. Each Leaf is of an oval form, but terminated by a sharp point, and they are hollowed. They resemble very much the Leaves of some of the Aloes: their colour is a fine green, and their substance beautifully reticulated; not in the least resembling other Leaves.

THE Stalk rises from the head of the Root, surrounded by these Leaves, and in the upper part twists itself into a kind of circle. It is very simple in its structure; and at first green, but afterwards reddish.

ON the top of this grows the Head; a part of very singular structure.

IT is of an oval shape, swelled almost into roundness, and is covered by a membranaceous Hood, called the Calyptra: this is extended loosely over the

the whole Head: it is gathered into a kind of Neck at the summit of the Stalk, and is continued beyond the extremity of the Head, in form of a beak, or long slender cylinder, is pierced at the top, and there rises out of the aperture a fine crimson body, oblong, and thickened at the end. Plate XVII. Fig. 1, *a a a*.

THIS is the state of the Head when the Moss is in full flower. In a younger Plant it is slender, and appears longer, and the Calyptra has its hard brown Ring at the point of the Beak, and is open there; but there is nothing of the purple Filament. In the Seeding state, the Head becomes yet more swelled, and the Calyptra being now not large enough to cover it, slips by degrees from the lower part, till at length it falls off. In this latter state there is seen a faded remain of the Filament at the top of the Hood, and nothing more.

THO' the object be minute, it may with care be separately examined. If the Skin forming the Hood be slit up, and drawn off entire, we see the naked Head, Fig. 1, *b b*. The Skin thus taken off is of the same reticular constitution with the Leaves; and it comes away entire with the cylindric Beak and purple Plume.

THE Head remains also entire, and is pear-shaped; small at the insertion, large at the other end, and is there terminated by a kind of Umbo, or low conic Button, Fig. 1. *c*. All this is perfectly green.

ON cutting the head longitudinally in half, see Fig. 2, its structure is found to be this. The Stalk, at its summit, swells into a spongy thick lump, Fig. 2, *a*; and from the summit of this part, which is solid, it expands upwards, into that pear-like form we see, *b b*, which is hollow: the Shell, *c c*, is of considerable thickness; but the cavity, *d d*, is equal to many times the measure of the Shell. From the center of the Fleishy lump, *a*, whose surface has swelled into this shell, rises a Seed-Vessel, *e e*. This is like a green cup, or drinking-glass, with a cover. The part which rises immediately from the solid mass, is a kind of Pedicle, *f f*. This expands into the body of the Seed-Vessel, *e*; and the Cover is radiated, *g g*.

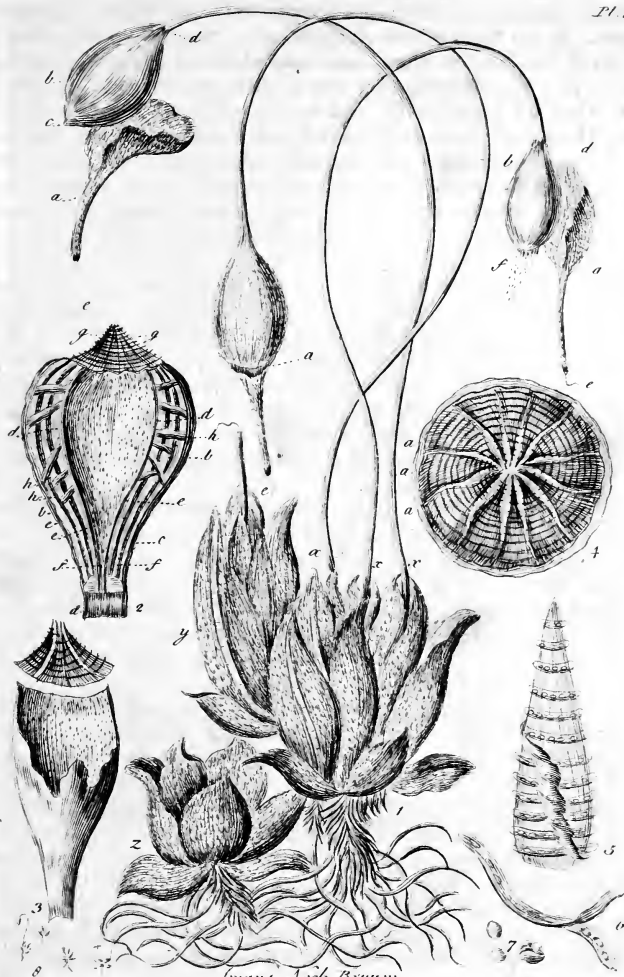
IT is easy to see this Seed-Vessel is of great importance in the nature and œconomy of the Plant. It rises in the center of the hollow Head, but does not nearly fill that cavity. There is a large space every way round it; and it is kept in its place, and fed, by numerous thick Vessels, *b b b*, which take their origin from the reticulated substance of the Shell, and are inserted into the Seed-Vessel. The Seed-Vessel and Corona, separated from the Head, are shewn at Fig. 3.

THE Hood, Fig. 1, *aa*, has no connection with the Head; it is merely a defence. It is a continuation of the Rind of the Stalk, and nothing else. It rises at the Neck of that Lump into which the Stalk swells at its summit, Fig. 1, *dd*; and being very thin in that part, it bursts and tears away there when the Head swells; and having performed its office of defending the Head while young, it falls off, and fades away. The purple Plumule, at its point, Fig. 1, *ee*, which to an unwary eye might seem a Stigma, is nothing more than the withered extremity of the Rind of the Stalk. This Rind forms a Knot, or swelling, at the summit, and terminates finally in this lengthened and twisted Cord. The Head has all its parts of fructification in itself.

THE thick lump of Flethy substance which crowns the Stalk, is properly the Receptacle of the Fructification: this rises into a kind of Fruit, as in the Figure, see Fig. 2, and is not unlike to it in shape; but in this minute Plant there is yet a separate Capsule within it. The hollow body within the cavity of the Head, is this Capsule, and it is filled with Rudiments of Seeds. The radiated Cover, *gg*, is a Crown of Antheræ, which, when more ripe, and open to the air, will separate, and shew themselves loaded with a fine Farina. This falling on the young Seeds, impregnates them, and they are then fit for growth.

IN the Plant in this flowering state, these Antheræ are but imperfectly distinguished: they rise from the verge of the Head, and bending inwards at the point, form a kind of low green Cone, Fig. 1. *c*. When the hood is fallen off, they harden and grow brown; they start at the Points, and then separate at the sides; and are soon distinct throughout, Fig. 1, *f*. Each is a flat Pyramid rising from the Ring formed at the top of the Head, without any Footstalk. The entire Crown is represented magnified at Fig. 4, and a single ray of it at 5.

THE substance of these rays is reticulated, like all the rest of the Plant, and they are covered with a delicate Membrane. The Farina is lodged in a kind of Chains, Fig. 4, *aaa*, round the substance of the Antheræ in many places. These Chains are formed of small oval Particles, see Fig. 5: these are the Globules of the Farina, inclosed in a single Membrane, which keep them at a distance from one another: see Fig. 6. They are thus doubly, indeed trebly secured from the injuries of the air, while they are taking their growth; first by the Calyptra, or loose Hood, which covers the whole Crown or range of the Antheræ themselves; then within the outer Film of the Anthera, the chains of Globules being lodged between the Coat and Substance, see 5; and finally by the Membrane, which



[illegible]

which connects them into that Chain. The Globules of Farina, entire and burst, are shewn at Fig. 7.—Such care has Nature taken, of the Seminal Plantule of this small Moss, before it is delivered to the Seed: for every Globule of this Chain contains a separate Particle of the Fleishy Substance of the Plant, rising from the reticular body of the Anthera, which is a continuation of it.

WHEN this Farina is to be dropped upon the Seeds, the process is this. The Hood, Fig. 1, a, first falls off; then the Antheræ, Fig. 1, f, separate and harden; after this the Membrane which covers the Anthera bursts on the inside, and along the edges, Fig. 5, and the Chains of Globules break and start out in length; but still the Membrane keeps its form. In this State the Anthera resembles the Snout of the Saw-fish, see Fig. 5, having a multitude of Teeth on each edge. The two opposite Teeth are always the two ends of a Chain of Farina, which has broke on the inside of the Anthera, where both the Membrane and this Chain are weakest; and a careful eye will trace easily the continuation of the line across the Anthera.

AFTER a time the Membrane which forms this Chain bursts lengthwise, 6. Every Knot is a Globule of Farina, which, when the Membrane opens, falls out, and the Mouth of the Seed-Vessel being open just below, it naturally lodges upon one or other of the Seeds. Each of these has a small aperture in the Crown, and the Globule of Farina bursting, the Plantule, with its defence of waxy-matter, which it has exactly as the large Plants, makes its way in. Thus the Seed of this Moss is perfected; and, when it is hardened, falls from the Head, and grows.

I HAVE observed, that it has been thought these swollen Particles in the Head of a Moss were Globules of Farina, not Seeds; and that the Head itself, tho' it have plainly all the necessary parts of Fructification in itself, has been called an Anthera. Reason, and its construction, seem to declare otherwise, and certainly experience does so.

THE established Characteristicks of an ANTHERA are, that it is a part of a Flower full of Farina. But the Head in this Moss is not a part, but an entire body, containing every thing belonging to a Flower, except Petals, which are of no consequence, and are wanting equally in many of the larger and more specious Plants. This HEAD is a CUP, formed as all other Cups of the outer Rind of the Stalk: the RAYS OF THE CORONA are ANTHERÆ, and their GLOBULES true FARINA. The hollow body in the Head is a real SEED-VESSEL; and the solid mass from which it rises,

together with the entire Shell of the Head, is a true and regular RECEPTACLE.

THE Characters of Farina are these: that it is a Powder, whose Particles burst with water, and discharge what have been called elastick Atoms. LINNÆUS adopted from M. NEEDHAM, the idea of these elastick Atoms; but he afterwards calls the contents of the Globule of Farina, an impalpable Matter; which is more exact.

THE Globules from these Rays of the Corona are very small; they burst in water, and there is discharged from them what has been called elastick Atoms, or impalpable Matter. It is, indeed, a minute Particle of the essential Substance of the Plant, covered with a waxy Substance, which being incapable of solution in the watery Juices of the Plant, keeps in distinct Globules.

THEREFORE the Particles lodged in the Rays of the Corona in this Moss are Globules of Farina.

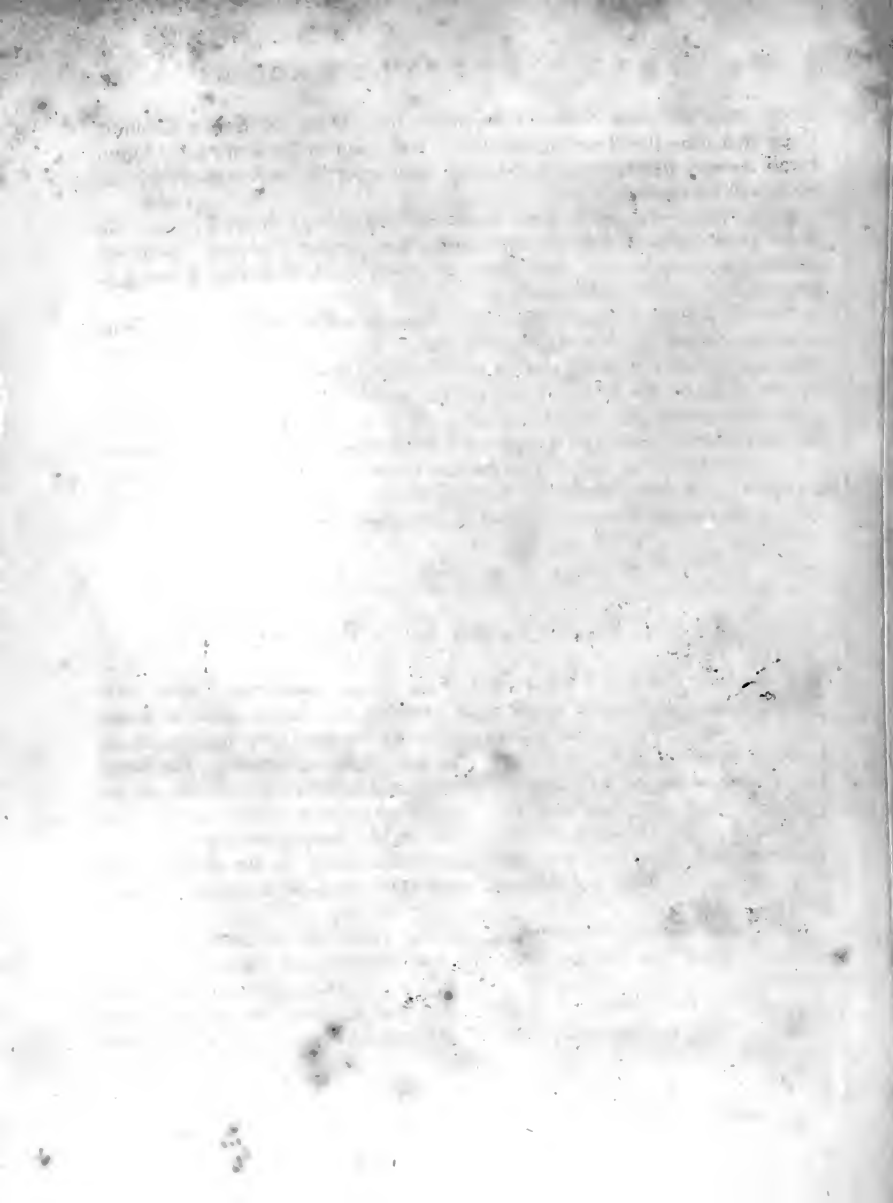
THE Characters of a Seed are these. It is a part of the Vegetable, containing the Rudiment of a new one, and ready to fall from the old Plant and grow; after it has been impregnated by the Farina. When a Seed is so minute as this of Moss, its distinction from a Farina must be sought partly in its negative qualities. Now, this Seed is a part separable by Nature from the old Plant, and capable of growth into a new one: It does not burst in water as Farina, nor when purposely broken has it any of that waxy matter found in all Farinæ. There is, indeed, a Plantule in it, delivered from the Farina, just as there is in all Seeds.

THESE reasons shew, the Powder lodged in the HEAD of Moss to be Seeds: If there be more proof wanted, take it from experience. The Plant here figured I raised from Seed gathered upon a wall at Westburn-Green, and sown upon that low wall of the Hyde Park Reservoir. This Seed was ripe in March. I sowed it in the first Week of April, and the Plants flowered this February. Nothing is easier than the Process of this minute article of Gardening. Scrape the surface of the Bricks, and of the Mortar between them, with a blunt Knife; take a large Tuft of the Moss in Seed-time, and draw its Heads over this rough surface; the Seeds will fall out, and tho' millions are lost, enough will be fixed to grow.

THE first appearance of the young Plants was in the Beginning of May: they were green Specks, like Dust; but a Microscope shewed they had Leaves. They remained thus till Autumn; but then they grew fast. The distinct Leaves appeared to the naked eye in October: four were spread out in a starry manner, and two rose in the center. In the next month



Various leaf of Polypody.



month they all grew clustered together, and began to form a Globule. From that time the Root increased very fast; and in December the young Heads shewed themselves: in February they ripened: and next month the Seeds will be perfect.

IN the same manner I have sown the little GREY BRYUM, upon the North-west part of the Queen's seat in Kensington Gardens, the stone-building near the water: these Seeds also were from Westburn green: another season will shew the success.

THIS is a point the more important, because a Pupil of LINNÆUS, from what he observed in a very peculiar Plant, has supposed the Seeds to be Farina; and distinguishing the Rudiment placed elsewhere, from all Seeds, by the name of PROPAGO, has supposed other MOSSES like that; and the great Master himself adopts the opinion. Errors, supported by such names, are very dangerous. Certainly in this Plant there are no such propagines, nor any thing so singular. The regular Seeds ripen in Heads containing Capsules; and every Plant has one of them. The Plant, in its natural size in the various Periods of Growth, is represented at Fig. 8.

C H A P. XLV.

Of the VARIOUS LEAF'D POLYPODY.

IT has been said in the Characters of the Seven Families of Plants, that the Ferns consist of a single Leaf, bearing the Seeds upon its back. Such are the upright Leaves, *a a*, of the POLYPODY here figured, as an instance of this family: See Plate 18: and such, occasionally, the lower and spread Leaves, *b b b*, might become: for howsoever different an aspect they wear, they are capable of growing up to the same height, and of breaking into the same divisions. When the Leaf grows up for Fructification, the indentings are continued down almost to the middle Rib, and the Leaf *b*, then becomes the same with the Leaf *a*, in all particulars.

It is not particular to this Plant, among the Ferns, to have two kinds of Leaves, the one barren, and the other florid: our common Rough Spleenwort, and the Osimund Royal, with many other, have the same Variations, tho' the difference in form is less; and therefore less conspicuous.

THIS Plant is a native of the East-Indies; found principally about the Stumps of old Trees in their Forests. The Botanists of earlier periods were

were acquainted with it. *CLUSSIUS* calls it *Polypodium Indicum*; and others *Polypodium folio Quercus*. The Root is tuberous, irregular, and brown; usually of an oval shape, and covered with a mossy matter on the surface. The first Leaves which rise from this, are oval, indented, of a brownish green, and placed on short Footstalks: these defend the succeeding Leaves, which carry the Seeds of the Plant; and they seem formed for no other purpose. The succeeding Leaves are raised on Footstalks, and deeply jagged, as our common *POLYPODY*; and these bear the Fructifications on their under sides. Round Clusters of Seeds are placed on the backs of all the Lobes or Divisions; and in their various stages of perfection we may, in a great measure, trace their origin.

THE first appearance is a rising of the surface of the Leaf, like a Papilla on the upper side; and this makes a minute hollow on the under part. By degrees the Papilla opens at the top, and there is an irregular, but roundish hole, with no green covering; but entirely white and spungy. At the same time clusters of yellow Seeds usually appear below; which increase in number, and, by degrees, the part of the Leaf over them loses its prominent form, and becomes flat, and sometimes hollow: the opening in the center still remaining a plain white Spot.

To explain this opening, it must be observed the Leaf is formed of two colourless Coats, with a green substance, the Blea, between them; amidst which several side Ribs run from the main Fibre in each Lobe, and inosculate with one another, forming a beautiful reticulation. These Ribs are Conic Clusters, covered with a little Flesh. Each, at its extremity, rises thro' the green part, or Blea, to the surface, and forms a clubby Head, which is open to the air, and is white and spungy.

THESE Extremities usually inosculate; but toward the point of the Leaf they are often single. From the Ribs, in their course, shoot others; and these last terminate in clubbed Heads in the middle of the Leaf. One of these always swells into the Papilla, and has its proper opening at the summit. Sometimes two of those Papillæ are form'd so near, that they run together: but then each has its proper opening.

EVERY Seed-Vessel is of a roundish form, and whitish; and its circumference is wound about with a jointed Ring. Each is supported by a long, delicate, transparent, Filament, by way of Footstalk, which is terminated by the Ring: And all these Footstalks rise from the under part of the original Papilla. The substance of the central part of each Seed-Vessel is spungy, like the open Head of the Papilla: The Ring is membranous,

as the Verge of the Leaf is; and its Joints are brown. Therefore the construction is this :

THE Papilla is the Receptacle of the Fructifications, formed from the white part of the Conic Clusters. From this rise numerous Filaments, crowned with their Rings of Antheræ: for each Ring is a Collection of Antheræ; every brown Joint of it being one. These Joints burst in water, as the Particles of Farina always do; but the central part never opens. This central part is in each a single Seed: the miracle is its situation; instead of being lodged in a Capsule, it is fixed to the complicated Antheræ, and contained within it: and when the Farina bursts, it receives immediate impregnation.

THUS the Process of Nature in the Fern is the same as in all other Plants. What we call the Seed, is a part, or continuation, of the Central Substance of the Stalk; which, when it has received from the bursting Farina the Rudiment of a new Plant, ripens, defends it, falls, and bursting by the warmth and moisture of the earth, grows.

THE Seed is at first an empty membranaceous Shell: when the Antheræ has burst, it appears full, and yellowish; and then being opened, we see plainly the Rudiment of a Plant, covered with a yellowish waxy matter.

WHEN the Antheræ bursts, a fine yellow, pulpy substance issues from them, so fine that it appears like smoke; and in the midst of this is seen a small oblong body, a minute Rudiment of a future Plant.

THAT these Joints of the Ring are Antheræ, is certain; for I have separated them entire from the Ring, and seen their Powder burst in that condition. They are oval and white: the brown colour they seem to have in the Ring being only shadow. I doubt not but the Fructifications of the other Ferns are of the same kind with these; and, probably, in many they are as distinct.

C H A P. XLVI.

LUXURIANT GRASS.

ANY GRASS would have served for an instance of the Plants of this great Family; for all have husky Covers for their Seeds, and simple Leaves, and jointed Stalks. These are the most obvious part of the Character: and whether we examine the low GRASS that starves upon the sun-burnt wall, or the tall Wheat, at Harvest, we see it equally: a simple, smooth,

smooth, and hollow slender Stem, swelling at distances into round, hard, paler, and more solid Knots, from whence arise the Leaves, covering usually the Stalk for a considerable part of their course.

THIS is the visible and common Character of the Family, and I have therefore selected a Plant which, besides this, shews something singular in the course of growth, a peculiar kind of luxuriance from the Rinds. This Species is frequent in our Northern Counties; and throughout all the colder part of Europe. VAN ROYEN and LINNÆUS of the moderns; and among those a little earlier, SCHEUKZER and the BAUHINES knew the Plant. They have distinguished it by the names *Gramen Foliis Junceis*, and *Foliis Setaceis*; the Rushy, or the Bristly Leafed GRASS, from the rounded form of its Leaves: but with good nourishment they will grow something broader.

SCHEUKZER ranges it among the Paniculate Spartean GRASSES; LINNÆUS once referred it to that Genus which he calls *FESTUCA*; but he has since removed it to the *POA*; to which, according to the Generic Characters, it most certainly belongs. The term *VIVIPAROUS*, which he has given as its distinction, is bold; but he has Genius with Philosophy, and has called into the service many Metaphors, and often happily. Strictly speaking neither is it Proliferous, tho' SCHEUKZER, and the rest, have distinguished it by that title. There are GRASSES in which the Seed grows in the Ear, and will produce a perfect Plant; but this has less title to that term; and the utmost we can attribute to it, is a strange and very pleasing luxuriance of the Rinds.

THE Root consists of many dusky Fibres, long, tough, thready, and not much divided. The Leaves rise in small tufts, and are perfect, but small GRASS; narrow and firm. The Stalks are also numerous. In barren ground they will flower at three inches high: when the Soil suits them somewhat better, they grow to five or six inches, and sometimes to a foot: and in this state it is that the Plant is most perfect; and from this it oftenest grows luxuriant. The Stalk rises surrounded with Leaves, and the whole Tuft with a few light Films.

THE Stalk has usually three Joints, one of which is always near the Root, and scarce distinguishable, because of the involving Leaves: sometimes a second is also very low: the upper one is always most conspicuous. The Stalk is pale and thin. The Joints swell into a little roundness, and are hard. One Leaf, as is usual, rises from each Joint; slender and small, as those from the Root, or very little broader. At the summit stands a flat Ear,



Lucuriant. Grapo.

THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and change. It begins with the first settlers, who came to the Americas in search of a new home. They found a land of vast resources and a people with a rich culture. Over time, the United States grew from a small colony into a powerful nation. It fought wars, made treaties, and built a government that has stood the test of time. Today, the United States is a land of opportunity and freedom, where people from all over the world come to live and work. The history of the United States is a story of hope and achievement, and it is a story that we can all be proud of.

The United States has a long and proud history. It is a land of freedom and opportunity, where people can live and work as they see fit. The United States has made many contributions to the world, and it is a country that we can all be proud of. The history of the United States is a story of growth and change, and it is a story that we can all be proud of.

Ear, with the Husks all turned, or nearly all, one way. Each has its slender Footstalk, and they play a little loose.

THE Husks are of a greenish brown, and naturally terminate at the same small size with those of the other GRASSES, the Flowers having, like them, their three Filaments and feathery Style: but where the Soil and Season join to give the Plant abundant Nourishment, the several Valves, or Parts of each Husk, lengthen into absolute Leaves, grassy, and perfect as those of the rest of the Plant, only shorter.

WHAT has been said of the Formation of the parts of Flowers, explains this; for these husky Films are of the nature of the Cup in other Flowers; and being only the terminations of the Rinds of the Plant, more Nourishment may make them continue to grow: as the rest of the Plant does not grow with them, they could not run into a simpler or more natural form: the Blades of GRASS which they constitute, being no more than extended Husks, whose lengthened portion being full of Juice, and having had no check in its growth, is green and tender; while the Base, where Vegetation had begun to cease, is hard and brown.

C H A P. XLVII.

Of the WINGED PALM.

AS in the preceding instance any GRASS might have expressed the Family of Grasses, here any PALM might have been chosen for that purpose, respecting the Family of PALMS; all having naked Trunks, Leafy at the Top; and the Fructifications placed on a kind of Ear, and produced within a Scabbard. I have selected this as the most distinctive in the Characters; for its simply Winged Leaves display the frondose Nature of the PALM Head, better than those which, being more complicated, and divided, seem to be themselves Branched.

AUTHORS of early time have known this species; and it is common and famous for its many uses throughout the East, and great part of South America. The Fruit is the Nux Indica of AVICENNA, and the Tree itself the PALMA NUCEFERA, and COCCIFERA of the BAUHINES, and other Authors.

THE Root is black, and spreading. The Stem, or Trunk, is a Foot and half thick; and in favourable, moist, and shadowy places rises to a great height. It is covered with the remains of certain Films, which grow

about the Rudiments of the decayed Leaves. It is soft at first, but hardens as the Tree stands longer. The Leaves spread only from the top; and in the midst rises a little above them a tender Cone, of a white juicy nature; which is the Base of the succeeding Leaves. This is delicate in taste when the PALM is very young, and still sweeter when advanced to maturity; but in the middle stages of growth it is somewhat austere.

THE Leaves are elegantly pinnated or winged; and while young their several Lobes naturally and elegantly bend back, and often meet one another.

AMONG the Leaves rise together the Fruit and Flowers. They are disposed very singularly upon a kind of branched Ears; and these, while young, are covered by a filmy Scabbard; which, when it has burst lengthwise, to let out the Ear, decays. The Flowers and Rudiments of Fruit are disposed on the same Ear; the Fruit on the lower part, and the Flowers toward the extremities of the Branches. The Flowers are small and yellowish; the Fruit is fixed close on the stronger part of the Ear, and grows to a great size: woody on the surface, and filled with a peculiar Liquor, and a firm Pulp.

THE disposition of the Leaves upon the Palm, and of the Flowers and Fruit upon the Ear, give a sufficiently plain and certain Character of this Family: tho' Botany has yet a great deal to learn on the article of their Impregnation.

THIS is the sixth of the Seven great and natural Classes called Families of Plants; the Seventh comprehends the common kinds of Herbs and Trees together; such as have none of these peculiar marks. There needs no instance to be produced of these: the Hellebore, the Winter Aconite, and Anemone, with the rest, figured in the preceding parts of this work, belong to the Seventh Family, and one might be an example as well as another.

C H A P. XLVIII.

The ORIGIN of the SEVEN FAMILIES, from the INTERNAL STRUCTURE.

THESE are the Seven great Arrangements of Plants; and they are thus distinguished by obvious Characters from one another. Those Characters depend on the Proportion and Disposition of their several constituents



The Winged Palm.

TABLE 1

tuent Parts ; from which results that difference in the fabrick of their Vessels, and in the course of their Juices, which is the immediate cause of the Forms which give those Characters.

Thus in the MUSHROOM kind, instanced in the Truffle, the Flesh being extremely small, and making only a thin Membrane, is not able to raise itself up in a Stalk, nor to force out the other parts in Fibres : therefore the original Shell, or Annular Rudiment in the Seed, swells without producing any external part ; and of necessity must form, and throw off, the new Annular Rudiments within its own body. Thus it is also with all the other Mushrooms, whose various forms are no more than extensions of the original Annule, in a more free manner ; no one of them ever having the common appearance of Stalks or Leaves.

IN the ALGA the Coats as well as the Fleehy Substance, are all thin : therefore the Plant can be only membranaceous. In the MOSSES, the inner Rind of the Root is the part most redundant, and best nourished : therefore this forces itself out in form of Leaves ; and even covers the Head with as plain a Reticulation of Vessels. The proof of this appears upon a mere inspection. We know all real Leaves have their proper Coat of Rind, their Substance of Blea, and their Ribs of Conic Clusters : but what in these Plants wear the form of Leaves may be traced in a plain and simple course, from the inner Bark of the Root or Stem only : from this they rise without receiving any other part : and their structure is not that of Leaves, but is the same with that of the inner Barks of all Vegetables, a Reticulation of Vessels within two simple Membranes.

IN the FERN kinds the Flesh is still weak, and thin, and seems no more than as a membranaceous Coat surrounding the Conic Clusters ; and rising no where without them. Therefore no Flowering Stalk can be formed ; but the Rudiments of new Plants are produced where those Vessels of the Conic Clusters, which do not return, terminate in the body of the Leaf.

IN the GRASSES, the Vessels of the outer Rind are large, numerous, compact, and hard : that Rind itself therefore has the same Character. The Flesh, which is thin in all other parts, swells at the Originations of new Circulatory Systems in the lengthened Stalk ; and hence arise the Characters of the Family. The Knots of the Stalk are owing to the swelling of the Flesh, which is, indeed, no more than proportioned to the great length between Joint and Joint ; and the natural hardness of the outer Rind gives the chaffy and dry firmness of those Husks wherein it terminates.

the Mosses are redundant in the inner Rind, the PALMS abound in Blea :

this forces itself out in numerous and vast Leaves, whose Bases, in a manner, form that Stem which they seem only to cover. And finally, in the common course of Plants the Flesh, as is most natural, has the predominance; and carries up the ascending Stalk, a firm, distinct, and vigorous support to the Fructifications.

C H A P. XLIX.

Of the EFFECT of LIGHT ON PLANTS.

HAVING seen, in a variety of instances, what Vegetation is, and what the Bodies are which are produced by it, we might here close the present Enquiry: but there remains a point of great importance yet to be discuss'd; tho' it be one not generally conceived as relating to the subject. What HEAT and MOISTURE can effect, we have seen; but there is a third Agent, LIGHT, of equal efficacy; tho', in the midst of its own brightness, hitherto obscure.

THAT singular property which is called the Sleep of Plants, and which had been admired, tho' not understood, led me to those Enquiries, in which I found LIGHT to be the Cause; and those have led to others, new all of them, and all wonderful; from the result of which I may be bold to affirm, that Vegetables owe their Bulk and Quantity indeed, to the Earth, softened by Water, and actuated by Heat; but their Forms, their Colours, and, in a great measure, their Qualities, to this hitherto unconsidered Agent, LIGHT.

A SEED committed to the Earth will grow, tho' it be covered up in perfect Darkness, but the Growth will be weak, and the Body itself, in the highest degree, deformed: a Seed of the same Plant, covered as closely, but with a transparent body, will grow as free, and be as well proportioned, as in the open air. Thus, if two Pease be sown in the same Border, and the spot where one stands be covered with a Box of Wood, and that where the other is placed, with a Bell-glass of equal bigness. The Plant under the Box will be slender, yellow, insipid, and almost leafless; that under the Glass will have its natural Proportions, and proper Colour: the Leaves will grow regular, the Taste will be leguminous, and the whole Plant well formed, and green.

IN our common Gardens, the Anemone is poor in Colour when it is under the shadow of Bushes; and I last year observed at Sion-House, that

even

even the common Laurustine lost the Blush which adorns its Flower, entirely, under the imperfect Shadow of the Elm Walk to the Water; while sister Shrubs of it, at a few yards distance, had the same Colour as those in the rest of the Garden.

THE Plants which grow in Caverns, and in Wells, tho' full of Vegetable Life, have very simple Forms; and scarce any thing of Colour beyond Green. They are all of one or other of the Four lesser Families, FUNGUS's, ALGÆ, MOSSES, or FERNS, whose unobscure Flowers confess the Obscurity wherein they were formed: nor have they any strength of Taste or Colour. On the contrary, the most specious Plants, the Rose-Hibiscus, and the Gloriosa, with their fellows, are children of the bright Sun of the INDIES.

ALL Plants are animated, as it were, by LIGHT: they have motions in their Leaves, and other parts, which they must perform, or perish: on these motions depend the courses of their Juices, and these are the effect alone of LIGHT. Those which are least animated escape common observation; but they have motions as certain, tho' less obvious; and those which have the influence most fully, mimic the Animal Nature. It is hence the Sensitive Plants shrink at the Touch: for in the Dark they shrink yet farther: nor can any thing but LIGHT raise them to the condition of this seeming Sensibility.

THE Growth of Plants, at least their regular Growth, as well as their absolute Life, depend not only on Warmth and Moisture, but on LIGHT: this moves their Juices, and upon this motion greatly depends their Encrease. If tender Plants be kept in constant Darkness, they lose their Leaves, and die. Thus Mr. LEE, of Hammersmith, at my desire, making the Experiment most fairly, killed two Tamarind Trees, and an Ab-rus; and would have killed an Erythrina, but that he gave it LIGHT in time, and recovered it. LIGHT keeps the Juices of the Plant in motion; and this preserves the whole. When it is not admitted these stagnate, and they ferment soon after; then the part falls off, and the Plant, wanting its necessary Organs, perishes.

As our LIGHT, which is interrupted by the Night, raises our Plants to Flower in a certain longer course of Time; those which enjoy the short Lapland Summer, rise from the Root to full Bloom in a Fortnight: this is the effect of perpetual LIGHT, the Sun, for that time, then never setting. For the same reason it appears, that the Plants at the bottom of the Sea are, in all Climates, as destitute of specious Flowers as ours in Wells: and while that universal glow is seen upon the Asiatick Shrubs and common
Plants.

Plants, those which grow at the bottom of their deep waters, are as simple and as poor as our own. It is for the same Reason several Plants of the lighter Regions, tho' they grow freely, will not flower in our Stoves: and hence more LIGHT will make some flower in Europe, which else do it rarely and poorly. The Brunswickian Amaryllis is one instance; and some of the more backward Aloes give another.

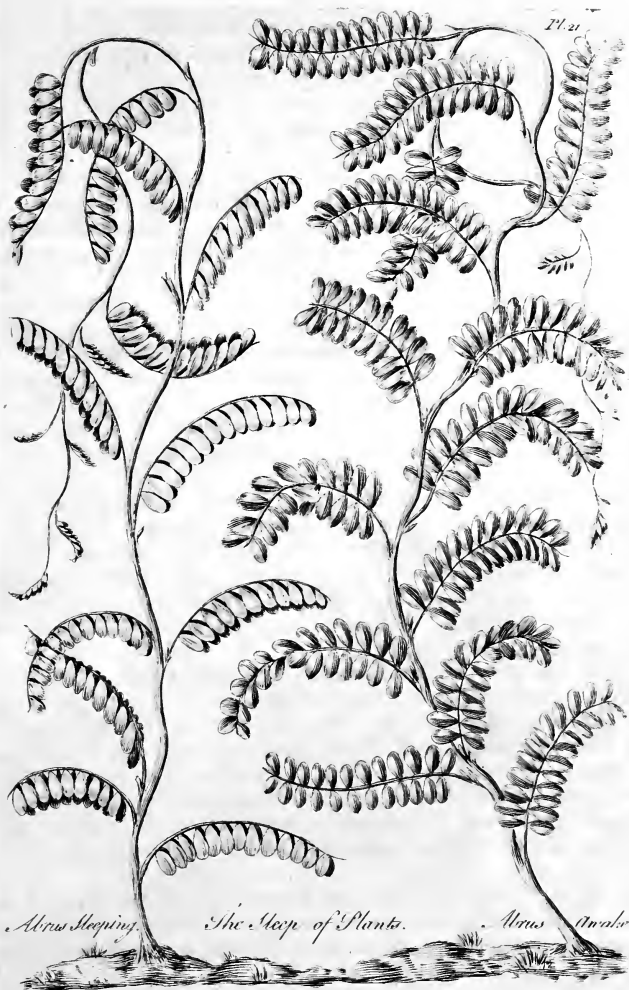
WHERE Vegetable Nature receives the greatest Perfection in Form and Colour, there also the Virtues of Plants are found the most exalted. The Spices, and the fragrant Gunis, come from the same bright Regions with the gayest Flowers; and from the imperfect trials we can make here, LIGHT has its share with Heat in their Production.

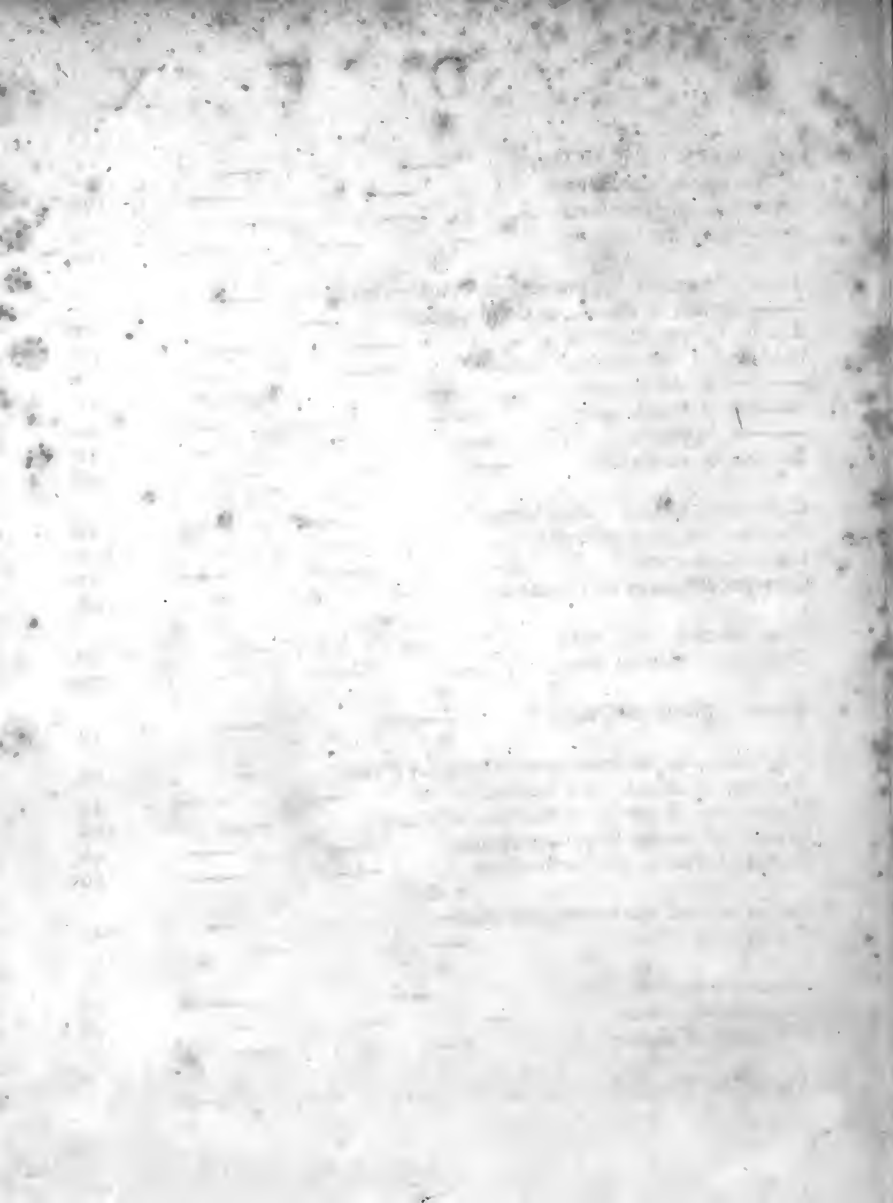
THESE are the most essential effects of LIGHT: but the most obvious is the expansion of the Leaves of Trees and Herbs; this is their state of Waking: opposed to that which has been called the Sleep of Plants. This closing of their Leaves I have been so happy to shew, by a multitude of experiments, is the effect only of the absence of LIGHT; and that their Expansion, which is called their Waking, is the immediate effect of the presence of that great Agent; and is proportioned always to its degree or quantity.

THE Plant which I have found answer the most readily of all to these Experiments, and which is therefore the best and fittest for them, is a young ABRUS. Such a one I have represented in the annexed Plate, see Plate XXI. in its two states of perfect Sleep and perfect Waking; the states of full Expansion and entire Closure. The Waking Plant is just what it appears in moderate Day-light: the Sleeping one is a representation of the same Plant in the Night.

IT cannot be needful I should repeat here what I have published in a preceeding Treatise on the Sleep of Plants; but it may be fit to say in general, that such a state as that represented in the Sleeping Plant, and which comes on naturally at Night, may be brought on at pleasure at Noon-Day, by shutting up the Herb in Darkness; and that the effect of LIGHT in the Expansion of its Leaves is so regular, that they may be made to rise and sink in small Gradations, by removing the Pot wherein it grows, to different parts of the same room, nearer to, or farther from, the Windows.

THE farther Effects of LIGHT on Vegetables, and the result of them, affords a subject worthy the best attention of all who love these studies: and, perhaps, a knowledge of this is all we want to perfect the Philosophy of Plants.





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